PROCEEDINGS

OF THE

Iowa Academy of Sciences

FOR 1898.

VOLUME VI.

EDITED BY THE SECRETARY.

PUBLISHED BY THE STATE.

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1899.

LETTER OF TRANSMITTAL.

DES MOINES, Iowa, December 31, 1898.

To His Excellency, Leslie M. Shaw, Governor of Iowa:

SIR—In accordance with the provisions of title 2, chapter 5, section 136, code 1897, I have the honor to transmit herewith the proceedings of the thirteenth annual session of the Iowa Academy of Sciences.

With great respect, your obedient servant,

H. FOSTER BAIN,

Secretary Iowa Academy of Sciences.

OFFICERS OF THE ACADEMY.

1898.

President.—T. H. MACBRIDE.

First Vice-President.—B. FINK.

Second Vice-President.—M. F. AREY.

Secretary-Treasurer.—HERBERT OSBORN.

Librarian.—H. FOSTER BAIN.

EXECUTIVE COMMITTEE.

Ex-Officio.—T. H. MACBRIDE, B. FINK, M. F. AREY, HERBERT OSBORN.

Elective.—S. W. BEYER, A. C. PAGE, W. H. NORTON.

1899.

President.—W. S. HENDRIXSON.

First Vice-President.—M. F. AREY.

Second Vice-President.—F. M. WITTER.

Secretary-Treasurer.—H. FOSTER BAIN.

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Elective.—S. W. BEYER, A. C. PAGE, W. H. NORTON.

PAST PRESIDENTS.

OSBORN, HERBERT	1887–88
TODD, J. E.	1888–89
WITTER, F. M.	1889–90
NUTTING, C. C.	1890–92
PAMMEL, L. H.	1893
ANDREWS, L. W.	1894
NORRIS, H. W.	1895
HALL, T. P.	1896
FRANKLIN, W. S.	1897
MACBRIDE, T. H.	1897–98
HENDRIXSON, W. S.	1898

MEMBERSHIP OF THE ACADEMY.

FELLOWS.

ALMY, F. F	Iowa College, Grinnell
ANDREWS, L. W	State University, Iowa City
AREY, M. F	State Normal School, Cedar Falls
BAIN, H. F	Geological Survey, Des Moines
BARRIS, W. H	Griswold College, Davenport
BATES, C. O	Coe College, Cedar Rapids
BEACH, ALICE M	State College, Ames
BEARDSHEAR, W. M	State College, Ames
BENNETT, A. A	State College, Ames
BEYER, S. W	State College, Ames
BLAKESLEE, T. M	Des Moines College, Des Moines
CALVIN, S	State University, Boulder, Colo.
CHAPPEL, GEORGE M	State Weather Service, Des Moines
CLARK, DR. J. FRED	Fairfield
COMBS, ROBERT	State College, Ames
CONRAD, A. H	Parsons College, Fairfield
CRATTY, R. I	Armstrong
CURTIS, C. F	State College, Ames
DAVIS, FLOYD	Des Moines
ENDE, C. L	Burlington
FINK, B	Upper Iowa University, Fayette
FITZPATRICK, T. J	Lamoni
FREDERICK, C. A	State Normal, Cedar Falls
FULTZ, F. M	Burlington
HADDEN, DAVID E	Alta, Iowa
HENDRIXSON, W. S	Iowa College, Grinnell
HOLWAY, E. W. D	Decorah
HOUSER, G. L	State University, Iowa City
KELLY, H. M	Mt. Vernon
KEYES, C. R	Des Moines
LEVERETT, FRANK	U. S. Geological Survey, Denmark
MARSTON, A	State College, Ames
MACBRIDE, T. H	State University, Iowa City
NEWTON, G. W	Cedar Falls
NILES, W. B	State College, Ames

Norris, W. H... ....Iowa College, Grinnell
Norton, W. H................................Cornell College, Mt. Vernon
Nutting, C. C ....State University, Iowa City
O'Donoghue, J. H....................................Storm Lake
Page, A. C................................State Normal, Cedar Falls
Pammel, L. H..................................State College, Ames
Reppert, F..Muscatine
Ricker, Maurice....................................Burlington
Ross, L. S.........................Drake University, Des Moines
Sage, J. R.....................State Weather Service, Des Moines
Savage, T. E..... ....Iowa City
Schlabach, Carl. ....High School, Clinton
Shimek, B..............................State University, Iowa City
Stanton, E. W...................................State College, Ames
Stookey, Stephen W........................Coe College, Cedar Rapids
Summers, H. E.................................State College, Ames
Tilton, J. L..............................Simpson College, Indianola
Veblen, A. A............ ....State University, Iowa City
Walker, Percy H........................State University, Iowa City
Weems, J. B......................................State College, Ames
Wickham, H. F..........................State University, Iowa City
Witter, F. M..Muscatine
Youtz, L. A...........................Simpson College, Indianola

ASSOCIATE MEMBERS.

Adams, P. E.... ....Durham
Baldwin, F. H............. ....Tabor
Barnes, William D......................................Blue Grass
Biering, Dr. Walter.......................................Iowa City
Bond, D. K...................................... Rockwell City
Bouska, F. W.............................. ....Ames
Brainard, J. M..Boone
Brown, Eugene...Mason City
Cameron, J. E... Cedar Rapids
Carter, Charles..... ....Corydon
Coburn, Gertrude ....State College, Ames
Crawford, Dr. G. E..................................Cedar Rapids
Deyoe, A. M...Britt
Eckles, C. H............... ....State College, Ames
Finch, G. E................... ....West Union
Gifford, E. H... Oskaloosa
Gow, James E...... ....Greenfield
Hill, Dr. Gershom H.................................Independence
Hume, H. H...Ames
Jenkins, P. W............................Simpson College, Indianola
Johnson, F. W..Grinnell
Lenocher, F. E...Panora
Livingston, Dr. H...Hopkinton
Miller, G. P..Des Moines
Miller, A. A..Davenport
Mortland, J. A... ....Cedar Falls

MUELLER, HERMAN.................... ....Iowa City
MYERS, P. C..Iowa City
NEWELL, WILMON.......................State College, Ames
OSBORN, B. F.......................... ....Rippey
PADDOCK, A. ESTELLA.................................Whitten
PECK, MORTON E.......................................Iowa Falls
REED, C. D.............................. ....Ames
RIGGS, C. B.....................................Rockwell City
RODWELL, W. W...................................Marshalltown
ROLFS, J. A.................... ....Le Claire
SAMPLE, A. F.......................... ....Lebnon
SCHULTE, J. I.......................... ....Ames
STEWART, HELEN W.................................Des Moines
VOLDENG, DR N. M.. ....Des Moines
WALKER, L. R..Oelwein
WALTERS, C. W.......................................Cedar Falls
WEAVER, C. B.................................Denver, Colorado
WILLIAMS, I. A.................................. ....Manly

CORRESPONDING MEMBERS.

ARTHUR, J. C......................Perdue University, Lafayette, Indiana
BALL, C. R..........................Missouri Botanical Garden, St. Louis
BALL, E. D...................Agricultural College, Ft. Collins, Colorado
BARBOUR, E. H.....................State University, Lincoln, Nebraska
BARTSCH, PAUL...............Smithsonian Institution, Washington, D. C.
BEACH, S. A...................................Geneva, New York
BESSEY, C. E.......................State University, Lincoln, Nebraska
BRUNER, H. L....................................Irvington, Indiana
CALL, R. E.............................. ....
CARVER, G. W..................................Tuskegee, Alabama
COLTON, G. H.............................Virginia City, Montana
CROZIER, A. A...............................Ann Arbor, Michigan
DREW, GILMAN C.............Johns Hopkins University, Baltimore, Md.
FRANKLIN, W. S.........................South Bethlehem, Pennsylvania
GILLETTE, C. P..............Agricultural College, Fort Collins, Colorado
GOSSARD, H. A....................................Lake City, Florida
HALL, T. P....................Kansas City University, Kansas City, Mo.
HALSTED, B. D............................New Brunswick, New Jersey
HANSEN, N. E..............................Brookings, South Dakota
HANSEN, MRS. N. E.................... ......Brookings, South Dakota
HAWORTH, ERASMUS................State University, Lawrence, Kansas
HEILEMAN, W. H................................Pullman, Washington
HITCHCOCK, A. S...............Agricultural College, Manhattan, Kansas
JAMESON, C. D..... ....
LEONARD, A. G...Oberlin, Ohio
MALLY, C. W.................. ....Wooster, Ohio
MALLY, F. W..Hulen, Texas
McGEE, W. J..................Bureau of Ethnology, Washington, D. C.
MEEK, S. E..................Field Columbian Museum, Chicago, Illinois
MILLS, S. J..Denver, Colo.

Osborn, Herbert .... State University, Columbus, Ohio
Owens, Eliza .... Bozeman, Montana
Parker, H. W. .... New York City, New York
Patrick, E. G. .... Department Agriculture, Washington, D. C.
Rolfs, P. H. .... Lake City, Florida
Sirrine, F. A. .... Jamaica, New York
Sirrine, Emma .... Woodstock, Illinois
Spencer, A. C. .... U. S. Geological Survey, Washington, D. C.
Stewart, F. C. .... Ithaca, New York
Todd, J. E. .... State University, Vermillion, South Dakota
Winslow, Arthur .... Kansas City, Missouri

PROCEEDINGS

OF THE

THIRTEENTH ANNUAL SESSION

OF THE

IOWA ACADEMY OF SCIENCES.

The thirteenth annual session of the Iowa Academy of Sciences was held in the geological rooms at the capitol building in Des Moines, December 27 and 28, 1898. In business sessions the following matters of general interest were passed upon.

REPORT OF THE SECRETARY-TREASURER.

To the Members of the Iowa Academy of Sciences:

The Academy has, during the past year, had a very satisfactory growth in the addition of sixteen associate members. The proceedings include 248 pages, presenting an interesting array of matter both instructive and useful. The appearance of the proceedings was delayed longer than usual on account of the legislative printing. Several papers presented were necessarily omitted on account of reaching our limit allowed for the volume.

The new code, by the omission of the words "with necessary illustrations," was construed by the executive council as not permitting the payment of bills for the engraving of plates and the account of the Star Engraving Co. for such work is unpaid, and I would suggest that authority be given for settlement from Academy funds. Part of the plates have already been provided for by the authors and possibly some others can be, so as to reduce the total necessary to pay from Academy funds. It will also be desirable to secure a change in the present wording of the law so as to permit illustration in future.

First notices only of dues were sent to members and there are quite a number who have not paid dues for past year, so that the funds in the treasury will be considerably augmented with the collection of these with the dues for coming year.

It is with great sorrow that I record the death of one of our most distinguished members, Dr. C. A. Schaeffer, who had been for a number of years associated with us. While his numerous duties prevented his contributing to our proceedings, he was always most cordial and hearty in his support and encouragement of our work. I also regret to announce the death of Mr. E. H. Lonsdale, one of our former fellows, recently engaged in the topographic work of the United States Geological Survey. Mr. Lonsdale contributed to volumes I and II of the Academy proceedings and was, while in Iowa, an active member. While Dr. James Hall, of New York, left Iowa some years before the organization of the Academy, his much regretted death is of more than passing moment to us. Dr. Hall was one of the scientists who earliest worked in Iowa, and we are yet deriving the benefit of his pioneer labors.

It is with peculiar regret that I contemplate this as my final report for, notwithstanding the effort sometimes necessary to fulfill the duties of the office, it has been a positive pleasure to me to give such time as was possible to the work and to watch the growth of the organization. May its prosperity and usefulness increase many fold in the years to come.

FINANCIAL STATEMENT.

Accounts and vouchers submitted herewith show receipts of $140.36 and expenditures of $71.84, leaving a balance on hand of $68.52.

SUMMARY OF RECEIPTS AND EXPENDITURES.

	Receipts
Balance from last year	$ 77.06
Annual dues from members	45 00
Fees from associate members	16.00
Sales of Proceedings	2 30
Total	$140.36
	Expenditures
Express and freight	$ 3 91
Reprints of authors' extras	32.00
Printing programs, blanks, etc	33.00
Postage on notices, collections, etc	2.56
Miscellaneous expense	37
Total	$ 71.84
Balance	68 52
	$140.36

Respectfully submitted,

HERBERT OSBORN.

The committee appointed to examine the treasurer's accounts reported as follows:

The accounts and vouchers of the treasurer of the Academy have been examined and found to be correct.

A. C. PAGE,
P. C. MYERS,
Committee.

The Academy established the following rule regarding illustrations:

Where the illustrations for any single article do not cost more than $2.50 the amount shall be charged to the Academy funds; where the cost is between $2.50 and $10 the cost beyond $2.50 shall be assessed half against the Academy and half against the author; where the cost is more than $10 all such excess shall be charged to the author.

The following amendments of the constitution were proposed and will be voted on at the next annual meeting:

Section iv to be amended by the substitution of the word "treasurer" where the word "secretary-treasurer" is used.

Section v (*a*) to be amended by the substitution of the words "a secretary and a treasurer" where the words "a secretary-treasurer" are used

Section viii to be amended by the substitution of the word "secretary" for the words "secretary-treasurer" as there used.

Section ix to be amended by the substitution of the word "secretary" for the words "secretary-treasurer" as there used. Proposed by

H. F. BAIN.

The following fellows and members were elected:

FELLOWS.

T. M. Blakslee, Des Moines, professor of mathematics, State University. Boulder, Colo., former member; Dr. J. Fred Clark, surgeon 49th Iowa Volunteers, former member; C. A. Frederick, Cedar Falls, assistant professor

of physics, Iowa State Normal; David E. Hadden, Alta, astronomer; J. H. O'Donoghue, Storm Lake, superintendent schools; T. E. Savage, Iowa City, assistant in botany, State University, former member; H. E Summers, Ames, professor of zoology, State College of Agriculture; H. F. Wickham, Iowa City, assistant professor of zoology, State University.

MEMBERS.

P. E. Adams, Durham; Dr. Walter Bierring, Iowa City; D. K. Bond, Rockwell City; F. W. Bouska, Ames; James E. Gow, Greenfield; H. H. Hume, Ames; P. W. Jenkins, Indianola; F. E. Lenocher, Panora; Herman Mueller, Iowa City; A. Estella Paddock, Whitten; A. F. Sample, Ames; D. H. Talbot, Sioux City; L. R. Walker, Clermont; Ira A. Williams, Ames.

The secretary was instructed to let each author see his own proof so far as might be possible.

The following officers were elected for 1899:

President—W. S. HENDRIXSON.

First Vice-President—M. F. AREY.

Second Vice-President—F. M WITTER.

Secretary-Treasurer—H. F. BAIN.

Elective Members of the Executive Council—S. W. BEYER, W. H. NORTON, A. C PAGE.

In general sessions the following papers were read in full or by title:

*HERBERT OSBORN—Observations on Hemiptera.

**J. H. O'DONOGHUE - Gas Analysis.

**LAUNCELOT W. ANDREWS—On a New Method for the Quantitative Determination of the Water Present in Concentrated Sulphuric Acid.

*MAURICE RICKER—The August Cloud-burst in Des Moines County.

**N. M. VOLDENG—Cell-formation and Cell-life.

*L. S. ROSS—A Simple Incubator.

*JAMES E. GOW—Forest Trees of Adair County.

*JAMES E. GOW—Effect of Sleet Storm.

*FRANCIS M. FULTZ—The Burlington Artesian Well.

*C. C. NUTTING—The Colors of Deep-sea Animals.

*F. M. WITTER—Observations on the Geology of Steamboat Springs, Colorado.

‡CHARLES R. KEYES—Cuesta Topography of the Crimean Peninsula.

‡CHARLES R. KEYES—Permian Series of Eastern Russia.

*CHARLES R. KEYES—Some Physical Aspects of General Geological Correlation.

*S W. BEYER—Buried Lœss at Ames, Iowa.

***H. FOSTER BAIN—Notes on the Drift of Northwestern Iowa. The extra-morainic drift of Northwestern Iowa has many peculiar characteristics and its age is in doubt. It has been provisionally correlated with the Iowan, but this seems now quite certainly wrong. There is an anomalous phase of the Kansan, as well as typical drift of that formation, in the region, and this has contributed to the confusion. The conditions governing the development of ferretto are discussed.

*FRANK LEVERETT—The Lower Rapids of the Mississippi River.

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* Published in this volume.
** Read by title. No copy furnished for publication.
*** Published in the American Geologist.
‡ Read by title. Abstract furnished.

†J. A. UDDEN—The Sweetland Creek Beds. These consist of some thin basal layers of blue arenaceous dolomite, overlaid by blue and black shale. They rest unconformably on the Cedar Valley limestone in places in Muscatine county, and are overlaid uncomformably by the coal-measures. Greatest observed thickness is 40 feet. The fossils are *Pychodus* and *Rhynchodus* remains, a few Lingulus and *Spathiocaris emersoni* Clarke, indicating that the formation belongs to the upper Devonian.

*J. A. UDDEN—The Pine Creek Conglomerate.

*J. A UDDEN—Diatomaceous Earth in Muscatine County.

*J. E. TODD—New Light on the Drift of South Dakota.

*B. SHIMEK—The Distribution of Lœss Fossils.

*B. SHIMEK—The Iowa Liverworts. A preliminary anotated list of *Hepaticæ* found in Iowa.

**J. FRED CLARK—The Agency of Flies in the Spread of Disease. (a.) Literature on the Subject. (b.) Experimental Proof of Possibility of Flies Carrying Germs of Typhoid Fever. (c.) Evidence From Observations at the Seventh Army Corps Camp of 1898.

*H. E. SUMMERS—A Generic Synopsis of Nearctic Pentatomidæ.

*T. E SAVAGE—A Preliminary List of the Mosses of Iowa.

*T. J. AND M. F. L. FITZPATRICK—Flora of Southern Iowa. Three trips made overland in a van the last season Large collections were obtained; notes written. The region surveyed being the two southern tiers of counties, from Decatur county westward to the Missouri River, a region of the state of which but little is known botanically. Quite a list of rare species and several species not before reported.

§B. FINK—Additions to the Bibliography of North American Lichens.

§C. R. BALL—The Genus Salix in Iowa.

§E D. BALL—A Review of the Cercopidæ of N. A. north of Mexico.

*P. C. MYERS—Preliminary Report on the Diatoms of Iowa. (1.) General distribution. (2.) Interesting localities. (3.) Diatomaceous deposits. (4.) Geographical distribution. (5.) Variation and probable cause.

‡T P. HALL—Extension of the Complex Algebra of the Plane to Three-fold Space.

*P. C. MYERS—Report on a Fossil Diatomaceous Deposit in Muscatine County, Iowa. (1) List of species with general distribution and habitat of each. (2) Probable conditions existing at the time the bed was formed.

**GEO. W. CARVER—Observations on Some Iowa Fungi.

**GILBERT L. HOUSER—The Physical Basis of Nervous Activity. The ultimate structure demonstrable in nerve cells; a review of methods of investigation; the changes which occur in nerve cells as the result of their activity; conclusions as to the seat of nervous energy and its mode of liberation.

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*Published in this volume.
**Read by title. No copy furnished for publication.
†Published in the Journal of Geology.
‡Read by title. Abstract furnished.
§Read by title. Copy arriving after meeting.

PRESIDENTIAL ADDRESS.

THE ACADEMY AND THE PEOPLE.

BY PROF. T. H. MACBRIDE OF THE STATE UNIVERSITY.

Gentlemen of the Academy:

Again, by the decrees of fortune, I appear before you as your presiding officer to extend to you the felicitations of the season and to congratulate you on this, our annual reunion. It is a fortunate thing that so many men can thus come up each from his own field, here to meet in friendly converse with his friend of like pursuit, of like employment, each to derive encouragement and stimulus for further and happier endeavor. This evening there are many reasons for special congratulation. Our roll of fellows and members is longer than ever before; our program shows a more general and widespread interest; every department of scientific work in the state would seem to be more assiduously cultivated than has hitherto been the case.

Let us hope that the enthusiasm which has thus far marked the progress of the Academy, and especially distinguishes the present session, may continue until every man of science in the state shall appreciate and feel its uplifting power. We ought to fill the largest hall in this city, and the time approaches when we shall.

It seems less necessary to enumerate here a list of the papers and publications of our membership during the year that is gone. Many of the more important are before you in the latest volume of our printed proceedings. Suffice it to say our members and fellows have not been idle. Some have been honored, and in their honors we rejoice to share, by transfer to wider fields and opportunities new, in other and distant states.

Our worthy secretary, Professor Osborn, to whose enthusiastic effort, more than to any other one thing the success of the Academy during these recent years is due, has already for

some months occupied the chair of zoology in the University of Ohio; Professor Hall occupies the chair of mathematics in the University of Kansas City: others are in still more distant states; one whose name is on our program is with the army of occupation in Cuba; and one, be it softly spoken, as is fitting, has gone on to his reward eternal. The sods of this, his newly adopted state, rest lightly yet above his fresh made grave. Charles Ashmead Shaeffer died September 23d. It is most proper that in the midst of our felicitations, in the gladness of our reunion, we should for a moment pause to lay upon that grave the wreath of grateful memory. Though, by his unceasing labors for the institution he so nobly served, he was in large measure deterred from actual participation in the work of this Academy as such, nevertheless, we always knew we had in him a sympathetic friend, and his constant attendance at our sessions was an inspiration to us all. Dearest to those who knew him best, the members of this Academy will mourn his untimely departure and grieve over their irreparable loss.

The report of the secretary and treasurer shows that the finances of the Academy are in satisfactory condition. Indeed, since the state has assumed the cost of publishing our proceedings, our expenses as a society are limited largely to the outlay incident to our sessions; printing, postage and matters of an incidental nature. However, the result is that while not a royal society, not under the patronage of the king nor of anybody in particular, we are, nevertheless, as suggested here last year, not quite independent; we are under obligation; we are in a sense bounden to the people of Iowa and it has seemed to me that it might be worth while for us to consider for a little time this evening the kind and amount of return which the people of the state may reasonably expect for their investment.

In the first place, the very existence and activity of such a body as this Academy is a factor of no small moment in the intellectual life of the community. Great universities in some parts of the world may exist, glow along for centuries, side by side with the greatest penury, superstition and intellectual night; within a mile of the University of Bonn I have seen a man ploughing with the family cow, while his wife and children, hard by, made hand-made brick in the open field. But such a situation fortunately is not possible, we may believe, in

America among our more active people The influence of a great intellectual center is not limited to the roster of its organization. The University of Michigan has educated the whole northwest, has influenced you and me, though we may never have seen its stately halls. And so I take it with an Academy like this; its work is far-reaching as the state among our own people, and far-reaching as science among the nations of the world; this by mere virtue of its existence, and all apart and distinct from the work it has been able to accomplish. The spectacle presented year by year of from three to four score, or more, intelligent men assembling at their own cost to discuss themes which offer no pecuniary returns, present or prospective, is at least sufficiently significant in this mercenary age of ours to demand attention. But there is something more. The problems we here discuss escape at length these halls, reach the public press, the firesides of the common people, and then who shall estimate the wide influence of the Academy as a constant impulse to intellectual life, more and more manifest and in every way most potent. Every discovery made by any member of this Academy, every new list of plants, every new bed of clay, every planed pebble or fossil tooth, every public discussion of printed report, stirs as nothing else the intellectual life of the community where such discovery appears or is reported, and redeems such segment of our population, in so far, from that fearful stagnation into which, apart from such stirring, humanity is so prone to fall. Our present popular and highly successful geological survey reaching as it does one after the other, in a most efficient way, every county in the state, is doing a wonderful work in the direction indicated, and I believe it is not too much to say that that survey is in a large measure due to the suggestion and organized effort of this Academy. At any rate, the survey is but carrying out in a more methodic and systematic way the work which has constantly largely engaged us here.

It is well for us thoroughly to understand this matter and betimes to put it clearly before the world. There are, as all history testifies, but two possible attitudes of the human mind; the one responsive to the stimulus of the external world, an attitude of inquiry, effort, search after truth with consequent ennobling glorious progress; the other an attitude of resignation, inactivity, a study of death rather than life, with resultant torpor, dry rot, necrosis of every noble power. If the

attitude of Americans thus far has been the former, the cause is not far to seek. The opening up and exploitation of a new continent has up to this time kept our people alive as have been no people elsewhere on the face of the earth, perhaps in all historic time; but that particular form of stimulus is passing. We are fast settling into conditions which are paralleled by the older nations of the world; I may not detail them here, but we all know that the stimulus of natural newness is passing, and I need not tell this audience that in the organized efforts of scientific men, in academies and royal societies, lies the only hope of the promethean fire. Such institutions are the open court of intellectual progress, the focus of inventive life. They, and they alone, foster and feed the inventive spark that shall at length blaze in the open field of discovery. Literature is glorious; but on occasion she hides in cloisters for a thousand years, while outside her gates all the world may slumber; art is wonderful; but art, too, is hemmed in by narrow, self-determined limits; philosophy is reflective, and is wont to lose herself in some far off Nirvana; it remains for science, for science only, to find for the human mind employ unceasing in duration, unlimited in scope, far-reaching in inquiry, beneficent in its purpose, touching with blessing the king in his palace, the poor man in his home, the savage in his hovel. Literature has no new themes. She still seeks her models in the millennia of the past, and turns the kaleidoscope worn by the service of three thousand years; philosophy attempts to reason upon data confessedly uncertain, and accordingly from century to century makes little progress; science alone finds problems forever new, bases her conclusions upon facts subject to constant verification, so that in an academy such as this there is perpetual reminder that the bounds of human knowledge are widening, and are yet to be enlarged.

In no college, in no university, however well organized, do we attain the same result. In a university every phase of human learning has its appropriate place and receives equal consideration; here the scientific method has full sway, naught enters to distract or to disturb, and in the light of friendly criticism each finds the help and encouragement of the other in the sifting of truth or the proclaiming of fact already ascertained.

In the second place, an academy such as ours is of highest

service to the state, in the fact that it is a perpetual protest against false science, science falsely so-called, insanity and nonsense of every description, into which civilized people are apparently so easily and constantly led astray. I think that I speak with the approval of most students when I say that the common people stand to-day more in need of our methods than of our facts. The habit of trusting only to accurate and oft repeated observation, the habit of correlating fact with fact, the habit of appealing constantly to some independent check, or verification, of accepting nothing that does not pass the ordeal of such scrutiny and test, such habit, if it could be imparted to our people now, and once for all, would certainly be of more value to them by far than all the facts we are likely to set before them for many a decade. The credulity, the absolutely infantile credulity, of some of our most intelligent people surpasses belief. The fact that "truth lies at the bottom of a well," that its attainment is difficult in the extreme, never occurs to most men, apparently, at all The song of the veriest charlatan meets readier credence than the voice of the laborious student. Accordingly one craze, or form of infatuation after another, sweeps over enlightened humanity. Forty years ago it was spiritism or spiritualism; to-day it is Christian Science. I leave the Christian apologist to disown the first portion of the binomial or not, as it may seem to him good; but I for one protest against the use of the word science in any such connection. Surely science has been long enough in the world to stand for something real in court, to possess a character and a reputation that has standing; surely science is entitled, once for all, to be relieved from the imputations of modern superstition and self delusion. The one thing for which the man of science strives is the ascertainment of facts, as these are appreciable by the senses aided by all instruments of precision; the one thing that so-called Christian Science denies, and all the while refuses, is what the senses of man declare to be a fact. There can by no possibility be science here where truth is studiously excluded and yet thousands of Americans, possibly hundreds of Iowans, are to-day inclined to spend their money and their time in pursuit of this latest delusion in the mirage book of time.

Of course I shall not be accused of refusing to my suffering fellow-man any form of solace which humanity, individually or collectively, may possibly bring to aid him; but let us have no

confusion; let us call things by their right names. Let mental, nervous and all sorts of more or less imaginary ailments be treated as the symptoms indicate; let effect be linked to appropriate cause as elsewhere in physiological research, and scientific methods may, at length, discover all attainable truth; but, let no man, forgetful of every principle of scientific procedure, and oblivious to its very first requirements, heaping up rubbish from the deservedly forgotten idealistic philosophy of the middle ages, go forth in the name of science to proclaim that there is no pain; that there is no disease; that there is no bodily ill; that "all, all is mind!" Science knows him not!

That such delusions find lodging among most excellent people, in no wise affects the case. The remedy lies, I shall still maintain, in the inculcation of real science which insists on the ascertainment of truth, and especially in the application of the method of science which trusts the evidence of the senses acting in their normal province and in a natural way. But is it not astonishing that almost every ancient delusion that aims nowadays to lift its head among enlightened men assumes to speak in the name of science, thus unwittingly paying tribute to the reputation which the scientific movement has made for itself in the world? Thus we have "occult science," strange contradiction of terms! and "esoteric science" and "mystic science" and "monistic science," "spiritualistic science," "theosophic science," and I know not what. Surely science has difficulties and perplexities of its own to deal with, sufficient that it may be allowed to protest against the imposition of such a burden of unheard-of accumulated rubbish. I repeat; the only remedy for false science is true science; the only knowledge that will save people from the constant recurrence of dominant superstition is found in that form of human knowledge and activity which this academy is set to foster. Literature will not do it; art will not do it; even religion, divine though her mission be, will not do it; has not done it. Her gospel seems to assume the spread of another gospel, that of common sense, and the gospel of common sense is modern science. If our people could once get into the way of looking at things as they really are, and judging the natural world on the principles of simple, clear-eyed, common sense, wisdom would at last be justified of her children.

But there is still another phase of the situation which I think ought to be mentioned here to-night. There is to-day, at

the end of the century, in the intellectual world everywhere, plainly a reaction against the distinctly scientific method of acting and doing. Thirty years ago, twenty-five years ago, science seemed about to sweep everything before it. Every phase of human thought was roused in a second renaissance, more far-reaching, and, as I think the future historian will declare, immensely more pregnant of result than was that earlier revival of the sixteenth century. But thirty years have passed and now the trend is different The freshness of the impulse is to most of us a memory; the world of thought has begun again to crystallize and although the force of that first upheaval is by no means spent, shores and continental outlines are all different from what they were before, nevertheless old tendencies, old ideas, old superstitions even, as just noted, are beginning again to lift their heads. The scientific movement as represented by this Academy is at an ebb and we must recognize the fact.

Now the reason for this condition is perfectly plain. In the first place, it is in fact a reaction. The generations of men have had time to shift once on the face of the earth. Men are lovers of ease. Science is aggressive. Under the reign of science the world is forever on the *qui vive*. Men are almost afraid to open their morning papers lest during the night science may have abrogated the necessity for food, written an analysis of love, or have so far confined to wires and rods the electricity of the planet that none shall be left for thunder-storms or auroral displays. The human mind cannot be always tense. The best lecture at last puts the auditors to sleep. This will account for any popular declension. Then again, there are hundreds of educated men whose conservative sympathies are all with the older views, to whom the real significance and purport of the scientific movement are but dimly seen. Not studying science itself, but only a presentation of it—I do not say misrepresentation of it—or turning from true scientific employ to the more fascinating fields of speculation, they make of science no more than a system of philosophy, comparable to any other one of the varied schemes of human dreamings that drift hither from the hoar antiquity of the race. It is thus that Mr. A. T. Balfour in his "Foundations of Belief" and Professor Haeckel in his "Confessions" meet in their assault on the methods of science, though separated by the whole diameter of the earth in the paths of their argumentation.

May I venture to suggest that the right honorable author, not being expert in the simple phases of scientific effort, has misconceived the mission and meaning of science altogether. He says of science, "Foundations of Belief," p. 94: "Its business is to provide us with a theory of nature." Never in the world! Its business is to depict nature as we find her and to give such account as may be possible of agencies which effect her changes. Science offers no explanation of nature. The man of science may frame hypotheses, but they are only as instruments of research for his own convenience, to be used and cast away when their purpose is attained, or when better are at hand. The facts attained by science, the methods of discovering truth would remain precisely what they are, whether our theory of nature be that of the eternity of a self-created universe, whether that of the old-time theologian who literally interpreted his six creative days, or whether with the Christian child we reverently say, "In the beginning God created the heaven and the earth." With the "meaning of the world," as philosophers put it, science has nothing whatever to do; she would simply teach man such use of the world as is conducive to his own safety and well-being, such a way of looking at the world as will deliver him from fear. Surely to the "meaning of the world" to "theories of nature" the race has given sufficient attention; is it not high time we should strive to comprehend that part of the world which most directly concerns us, and which has all the while lain unnoted within our reach? But even here Mr. Balfour would discredit science. Basing an argument on what he terms "mental physiology" he impugns the evidence of the senses; he declares that science has no evidence of the existence of the world of which it tells, is based upon an illusion, exists because of an erroneous view of the natural world. The plain, every-day man of science can for once scarcely trust his eyes as he reads such pages.

Now, to any one with sufficient mental equipoise to abide by the earth, to stick to that which the whole experience of animate creation in all past ages has proven true, to any one who abides the common appreciation of fact, such a book, as far as the methods of science is concerned, appears simply as a *jeu d'esprit*, a bit of dialectic humor; but to multitudes of people who will not do this thing, who, on account of innate prejudice,

or what not, are not especially friendly to the scientific movement, such an argument will appear conclusive, demolishing in a sentence all that fifty years of science has built up. Whether such argument takes with it electric lights and cars, bacteriology, modern surgery and photography, is not so clear.

But perhaps the most curious index of the present ebb is scientific interest and enthusiasm comes from a quarter where we should least expect it, from philanthropy or altruism, as in these days we are taught to say. The eccentric Russian nobleman, Tolstoi, regarded in many quarters as the modern oracle of all efforts for social amelioration, he, too, has a grievance against science. His is the most marvellous complaint of all. I quote from the Popular Science Monthly, July, 1898:

"The strong, sensible laborer supposes that men who study and are supported by his labor, shall be able to tell him where to find happiness. Science should teach him how to live, how to act towards friends and relatives, and how to control instincts and desires that arise within him, how and what to believe. Instead of telling him these things, science talks about distances in the heavens, microbes, vibrations of ether and X-rays. The laborer is dissatisfied. He insists on knowing how to live. The essential thing is the total view of life, its meanings and aims. Science cannot rise to that view, religion alone can do so."

I consider this a most remarkable utterance, but it simply shows how very far off an intelligent man may be in this year 1898 from a true appreciation of the method, the work and the mission of natural science. To declare that science has not been a blessing to earth's toiling millions can be possible only to a man who chooses to hide himself amid the serfs of benighted Russia, where aristocracy of church and state still holds millions in the superstitious degradation of medieval ages. Surely everywhere west of Russia, there is not a workingman who does not by virtue of the progress of science find himself to-day better housed, better warmed, better fed, better taught in health and better nursed in sickness than ever before in the whole history of the race. The light of science converts night into day before his footsteps; for a mere pittance, a small fraction of his daily wage, he journeys to and from his work in style befitting a prince; if he be sober, his home is the abode of comfort, the best knowledge of the world is spread before his children, gifted men taught in the ways of science

are instantly at his summons everywhere to save him and his from suffering and disease. Nay, the very fact of the matter is that science made possible the continued existence of Mr. Tolstoi and his serfs, when a few years since but for science-invented steamships and telegraphs all the people of southern Russia would have perished by starvation together. Mr. Tolstoi probably appreciates this, but he fancies that the world suffers more from selfishness and tyranny than from ignorance of nature and her laws, which may be true; but the antidote for tyranny is intelligence, for selfishness wisdom, and in the winning of such virtues science is certainly a contributor not to be despised. The most democratic statesmen in Europe to-day are not the men of religion, the clericals, but the men of science. It is one function of this Academy, at least, to keep the people of Iowa from lapsing in their allegiance to what may well be called, as it seems to me, the noblest and most beneficent intellectual movement of modern times.

It would seem gratuitous thus to enter upon a defense of science or the scientific methods; they really need no defense; but after all, it is well sometimes to declare the truth. In fact science, as such, has never been popular. As usual, results only are popular. The toilsome, laborious researches recounted in the tomes of all the academies of earth are not attractive, not popular. They mean long days and nights of weary labor. Faraday and the electricians before him discovered and knew nearly all that we know to-day concerning induction and alternating currents, but Faraday never heard through a telephone the voice of his friend, nor walked in the blaze of an electric light. That came later. It is easy for men to sit by an incandescent lamp and write criticisms of the scientific method, but such men ought at least be honest enough to acknowledge their indebtedness, to own that it pays to have scientific work done, however unsatisfactory the method of the scientist may seem to them to be. How many men there are ready to ridicule meteorology, the latest effort in the field of scientific research, and yet every year, even with our present imperfect methods and knowledge, the saving to humanity by our weather service in property, health and even life itself is of moment incalculable. Besides, who shall doubt that the day is coming when the currents of the upper air may be mapped and known as exactly, perhaps, as those of the

more solid ocean, and although we may never be able to control one or the other, we may better and better adapt ourselves to their vagaries as time goes by.

In view, then, of the present need of our own people, and in view of the present status of the world of thought, it does seem to me that the necessity of our organization takes on new importance. We should, as never before, encourage each other to good work, in every way strive to foster the spread of science and its methods among the people of this good state. We are as the scientific public servants at Washington, a "university unorganized," and while we may guard as zealously as may be needed our fellowship, the council of the Academy, let us yet welcome to membership everybody in this whole state who has within him the impulse of a scientific spirit. This fair city of Des Moines surely numbers in its population scores of men in all walks of life who have our work at heart and who, if organized, might second, as nothing else could do, the efforts of this academy. It is one of the beauties of scientific investigation that the problems of science are about us everywhere. Those about the city of Des Moines are quite as interesting, fascinating, no doubt, as any others within an equal area on the face of the earth. It remains only that men open their eyes and see. A local academy of science in this, the capital city, if I may be permitted to suggest, would be a wonderful adjunct to this association and stimulate in a peculiar way an interest in science everywhere. Davenport has for many years maintained such an institution, famous throughout the world. The geologists of Iowa cannot alone maintain our work, nor can the botanists, nor the chemists, the mathematicians or astronomers, but if all unite, we can develop programs of universal interest, and thus more surely attain that prestige as an institution which would seem to be in keeping with the reputation of our state.

And let us not for a moment fear that our labor is in vain. The future of Iowa is hardly dreamed to-day by the most enthusiastic of its optimistic citizens. I look forward to the time, and that in no distant future, when the center of wealth and power in this great republic shall be within 150 miles of where we are this evening gathered. It is coming sure as the swift revolving years. The Mississippi valley is certain to be the empire of the world. When that day comes the faithful effort of this Academy will find its own reward. It will then

be seen that we, too, were foundation builders, that upon our work has risen a temple of science commensurate in usefulness, beneficence and inspiration, with the imperial destiny of our river-bordered state.

THE COLOR OF DEEP-SEA ANIMALS.

BY C. C. NUTTING.

The purpose of this paper is to explain the phenomena of bright colors among marine animals living in the sea beyond the depths to which sunlight can be supposed to penetrate to such an extent as to render bright colors visible. Although there are doubtless actinic effects of sunlight at considerable depths, we are safe, I think, in saying that colors cannot be clearly distinguished at a depth greater than 100 fathoms. Photographic experiments show that the "extreme limit of effect of the sun's rays on sensitive plates is at a depth of 250 metres," or less than 125 fathoms. As to the facts concerning coloration of deep-sea animals—and the deep sea may be considered from our standpoint as any depth below 100 fathoms—all our information leads to the conclusion that the phenomena of bright colors are present in all groups. The main sources from which I have drawn this conclusion are the "Challenger" Reports and Narrative, "The Three Cruises of the Blake," by Alexander Agassiz, and my own observations, most of which are recorded in my narrative of the "Bahama Expedition" sent out by the State University of Iowa. Professor Mosely, of the Challenger staff, says:*

"Peculiar coloring matters giving absorption spectra have now been found to exist in all the seven groups of the animal kingdom. The echinodermata and cœlenterata appear to be the groups which are most prolific in such coloring matter. Pentocrinin and antedonin seem to be widely diffused in immense quantities through the tissues of the crinoids in which they occur; and the echinoderms generally seem to be characterized by the presence of evenly diffused, abundant and

*Quarterly Journal of Microscopical Science, xvii, p. 1.

readily soluble pigments." Again he says "the same coloring matters exist in deep-sea animals which are found in shallow water forms."

Alexander Agassiz says that there are many "vividly colored bathyssal animals belonging to all the classes of the animal kingdom and possessing nearly all the hues found in types living in littoral waters."* He notices the scarcity of blue color, however, having found it only in an encrusting sponge and blue crustacean eggs. The following statements are important: "There is apparently in the abysses of the sea the same adaptation to the surroundings as upon the littoral zone. We meet with highly colored ophiurians within masses of sponges themselves brilliantly colored at a depth of more than 150 fathoms." "While we recognize the predominance of tints of white, pink, red, scarlet, orange, violet, purple, green, yellow and allied colors in deep-water types, the variety of coloring among them is quite as striking as that of better known marine animals." "There is as great a diversity in color in the reds, oranges, greens, yellows and scarlets of the deep-water starfishes and ophiurians as there is in those of our rocky or sandy shores.

"Among the abyssal invertebrates living in commensalism the adaptations to surroundings is fully as marked as in shallow water. I may mention especially the many species of ophiurians attached to variously colored gorgonians, branching corals and stems of *Pentacrinus* scarcely to be distinguished from the part to which they cling, so completely has their pattern of coloration become identified with it. There is a similar agreement in coloration in annelids when commensal upon starfishes, mollusca, actiniæ or sponges, and with crustacea and actiniæ parasitic upon corals, gorgoniansor mollusks. The number of species of crustaceans * * * colored a brilliant scarlet is quite large." "Large masses of brilliant orange-yellow or brownish-pink sponges are constantly dredged."

The results of my own observations fully confirm the above statements of Agassiz.

Among the crustacea we found that a bright scarlet was very common, while the remaining species were generally either green or pale colored. One remarkable exception was a bright blue *Solenolambrus*. The echinoderms were particularly striking in their colors. Yellow and purple comatulidæ

* "Three Cruises of the Blake," Vol. I, pp. 310 and 311.

abounded in deep water near Havana. One ophiurian was brown, conspicuously marked with white, others were marked with purple and deep violet. The simple-armed basketfish were bright yellow, or bright yellow barred with brown, or deep orange and rich chocolate. A *Luidia* was a rich chocolate with conspicuous white spines. Among the sea urchins may be noted a *Coelopleurus* with crimson and white spines, a *Salenia* with vermilion and white barred spines, an *Aspidodiadema* with spines banded with purplish velvet and white, a very brilliant *Coeloplourus* with spines barred carmine and white and a test with alternating chocolate and orange zones, an *Echinus* with a beautiful green test ornamented with white diamond-shaped patterns. The cœlenterates tell the same story; gorgonidae of brilliant crimson, orange, yellow and scarlet, corals red and pink and rose color and bright yellow plumularian hydroids.

The following general statements seem to me to be justified concerning the coloration of the animals of the deep sea:

First.—The coloration is fully as brilliant as in shallow water, although perhaps not so varied.

Second.—The reds, orange, yellows, violet, purple, green and white predominate.

Third.—The colors, when they occur at all, are apt to be in solid masses in striking contrast, or the whole animal is of a uniform brilliant coloration. Fine patterns are very scarce and nature seems to have used a large brush in adorning her children of the depths.

Fourth.—There is a conspicuous absence of blue color among all groups. But two exceptions, a sponge and crab, have been noted.

A brief reference to the physical conditions of the deep sea is necessary to the proper understanding of the discussion in the latter part of this paper.* These conditions are:

First.—Great pressure, which of course increases with the depth. At a depth of 1,000 fathoms, the pressure is one ton to the square inch, a pressure 120 times greater than that to which we are subjected; while at 3,000 fathoms, the pressure is equal to that of 400 atmospheres Curiously enough, this enormous pressure does not seem to greatly affect the animals subjected to it. The bodies of many of them are composed

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* Most of the data in this paper concerning physical conditions are taken from "The Three Cruises of the Blake," Agassiz, chapter xiii.

largely of water, which is nearly incompressible, while many invertebrates possess abundant skeletal tissues of limestone usually permeated by profusely branching canals containing watery fluid (echinoderms, corals, etc), or consisting of small particles or spicules, embedded in a watery coenasarc (alcyonaria, sponges), or with an external chitinous investment (crustacea).

When fishes are brought up from great depths their tissues almost fall apart, on account of the release of pressure; the swim-bladder projects from the mouth and the eyes are greatly protruded.

Second.—Deep-sea animals are subjected to a comparatively uniform low temperature. This temperature is between 38 degrees and the freezing point at all places below 150 fathoms. As we near the poles this low temperature approaches, and finally reaches, the surface.

Third.—Absence of wave novements. In many places, however, there is a steady mass-movement of the water in the shape of currents.

Fourth.—Practical absence of sunlight. By this I mean that the light penetrating to a depth below 100 fathoms can not be regarded as sufficient to enable such eyes as ours, and probably all eyes, to distinguish between colors.*

Fifth.—The presence in many places of animals giving forth phosphorescent light. This being an important phenomenon for our purpose, I have gathered together considerable evidence to show the extent to which this light-emitting power prevails among abyssal forms. It seems that phosphorescent light is found among the following groups of deep-sea animals: *Fishes*, along the lateral organs or on the head. *Salpa:* the Blake expedition secured specimens which were several yards in length and highly phosphorescent. Many *crustaceans, cephalopods.* Among the Challenger material were specimens having very efficient phosphorescent organs on the lower surface, and not only was the light emitted, but lenses were found for concentrating the light as does a bull's eye lantern.† *Ophiurians*, *Pennatulidæ*, which are described as

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* Professor Verrill, however, maintains that a pale green light penetrates even to great depths. (See report of Commissioner of Fish and Fisheries, 1882, pp. 1054-1056.) This point will be discussed later.

† These remarkable structures were described before the zoological section of the A. A. A. S. at the Detroit meeting by Prof. William E. Hoyle, in a paper that was not published.

being brilliantly phosphorescent, *Gorgonidæ*, *Antipathidæ*, *Hydroida* and many *jelly-fishes*. Among the *Protzoa*, the noctiluca is perhaps the most widely diffused and numerically the greatest of all.

It should be remembered in this connection that it is altogether probable that the phosphorescence of deep-water forms, even where present, is only exceptionally discovered. While dredging operations are under way the work is usually done by daylight and the specimens are sorted and cared for as quickly as possible, only a small portion from considerable depths being alive when brought to the surface, and only a fraction of these being kept alive for nocturnal observations.

Under these circumstances, the occurrence of phosphorescence would be, as I have said, only exceptionally noted, even were it abundantly present in the forms studied. When we consider the above list of phosphorescent forms that have been recorded in spite of the conditions just referred to, it will be conceded that the actual amount of this light must be far greater than the face of the record shows.

It is well to bear in mind also, in this connection, that many of these phosphorescent forms, especially among the fixed cœlenterates, are aggregated together in masses on the sea bottom: No one can have had much experience in dredging in rich localities without noticing this. Agassiz speaks of "forests of gorgonians which become luminous by disturbances due to currents or other movements," * and I have frequently been surprised, when dredging on the Pourtales Plateau, at the immense quantities of echinoderms and cœlenterates secured at a single haul, indicating a profusion of life on definite areas of the sea bottom.

Taking the above facts into consideration, it is safe to say that phosphorescent light is a very characteristic and widely spread phenomenon which must enter into our discussion of the physical features of the deep sea.

It now becomes necessary to consider very briefly the nature and extent of organs for the perception of light and color with which the dwellers of the deep sea are endowed.

On this point Agassiz has the following statement: †

"We should not forget on the one hand that blind crustacea and other marine invertebrates without eyes, or with rudimentary organs of vision, have been dredged from a depth of

* "Three Cruises of the Blake," p. 308.
† "Three Cruises of the Blake," p. 307.

less than 200 fathoms, and, on the other, that the fauna as a whole is not blind as in caves, but that by far the majority of animals living at a depth of about 2,000 fathoms have eyes either like their allies in shallower water, or else rudimentary, or sometimes very large, as in the huge eyes developed out of all proportion in some of the abyssal crustacea and fishes; and undoubtedly adapted to make the most of the little light existing in deep water."

Verrill bears practically the same testimony:*

"That light of some kind and in considerable amount actually exists at depths below 2,000 fathoms may be regarded as certain. This is shown by the presence of well-developed eyes in most of the fishes, all of the cephalopods, most of the decapod crustacea and in some species of other groups. In many of these animals the eyes are relatively larger than in the allied shallow water species." This author thinks that the rudimentary eyes in many gastropods are due to burrowing habits.

It may be said in general that a greater proportion of eyes in abyssal regions are either rudimentary or wanting, on the one hand, or unusually large and effective, on the other, than in shallow water.

We now come to the main purpose of this paper—the attempt to explain the phenomena of coloration among animals of the deep sea. The theories heretofore advanced may be briefly summarized as:

First.—The vain and impotent conclusion that this profusion of color is meaningless. Beddard frankly makes the following statement:† "The inevitable conclusion, therefore, from these facts appears to be that the brilliant and varied colorations of deep-sea animals are totally devoid of meaning; they cannot be of advantage for protective purposes, or as warning colors, for the single and sufficient reason that they are invisible."

This sort of unconditional surrender is unworthy of the scientific spirit of the age. Beddard, however, it must be remembered, delights in finding evidence whereby he can throw discredit on the Neo-Darwinian school. It would have been much more to the point had he contented himself with saying that the utility of these colors had not as yet been explained.

*Report of Commission of Fish and Fisheries, 1882, p. 1054.
†Animal Coloration, p 37.

Second.—The green-light theory of Verrill. This is an attempt to explain brilliant coloration as protective.* He says in effect that sunlight penetrates to even the greatest depths and that only green rays reach those regions. He calls attention to the fact that the reds are the predominant, conspicuous colors in deep-sea forms and concludes that in a green light red would be invisible and thus the color would be protective.

Two objections present themselves to this theory. In the first place, it is incredible that a sufficient amount of sunlight penetrates to great depths to render protective coloration necessary.

Agassiz, whose knowledge of the deep sea is unsurpassed, says: †

"We may imagine a reddish, yellow twilight at a depth of about fifty fathoms, passing into a darker region near the 100 fathom line; and finally, at 200 fathoms, a district where the light is possibly that of a brilliant star-light night."

Now, when we remember how little of color can be seen in the most brilliant moonlight, and how soon all colors but white, if that be a color, are rendered undistinguishable at the approach of dusk in the evening, it becomes evident that our credulity cannot meet the requirement of this theory, *i. e.*, that green rays penetrate even to 2,000 fathoms or more in such quantities that protective coloration is needed. Again, even if it should prove that light does thus penetrate, animals would be equally well protected by neutral tints without the lavish expenditure of pigment which is so conspicuous among deep-sea forms.

The third and last theory regards the presence of bright colors and of functional eyes in so many groups as conclusive evidence that light is present in the abysses of the ocean, but considers that the widely diffused phosphorescent light, and not sunlight, is the aid to vision. This theory was adopted by Dr. W. B. Carpenter and Sir Wyville Thomson, and is the view which the present writer regards as the most reasonable.

Let us briefly recapitulate the facts which are important in this discussion:

I. *As to coloration of deep-sea animals.*

(*a*) Brilliant colors are common in all groups.

* Report of Commission of Fish and Fisheries, 1882, p. 1054, et seq.
† "Three Cruises of the Blake," p. 305.

(*b*) Reds, yellows and greens predominate.

(*c*) These colors are in masses, usually in striking contrast.

(*d*) Commensal associations of similarly and brilliantly colored animals are frequent.

II. *As to physical conditions:*

(*a*) Great pressure.

(*b*) Uniform low temperature.

(*c*) Practical absence of sunlight.

(*d*) Aggregation of animals in limited areas.

(*e*) A considerable amount of organic matter near the bottom.

III. *As to visual organs among deep-sea animals:*

(*a*) They are possessed by a majority of animals that normally possess them in shallow water.

(*b*) They are often of great size among deep-sea forms.

(*c*) They are often, on the other hand, either rudimentary or aborted.

IV. *As to phosphorescent light:*

(*a*) It is found among practically all classes of deep-sea forms.

(*b*) It is often of remarkable brilliancy. I, myself, have seen it so brilliant, on the surface of course, that ordinary print could be read from the deck of a vessel.

(*c*) It is possessed by animals that are known to be aggregated in immense quantities at certain spots at the sea bottom.

(*d*) It has the remarkable actinic property of rendering particularly conspicuous the reds, yellows and greens.*

Here, then, it would seem that we have a light that would render the characteristic colors of deep-sea animals, *i. e.*, the reds, yellows and greens, conspicuous, and no less nor more explicable than similar colors among their shallow-water relatives. In many cases they are doubtless to be regarded as warning coloration, as in the sea urchins, whose sharp spines are frequently banded with brilliantly contrasted red and

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*Mosely found that the phosphorescent light emitted by certain marine forms consisted of red, yellow and green rays only, and adds: "Hence, were the light in the deep sea derived from this source, in the absence of blue and violet, only red, yellow and green colors could be effective." (Quoted from Agassiz' "Three Cruises of the Blake," p. 310.)

white. This may also be true of bright red gorgonians, pennatulidæ and sponges, with their glassy spicules, and red corals, with their very large nematocysts.

The various cases of commensal association, such as the ophiurians, resembling the brilliant gorgonians upon which they climb, would thus be readily explained as instances of protective resemblance.* Among the crustacea the numerous cases of bright red, red and white or green coloration may be possibly capable of explanation along the lines of directive coloration, whereby the individual may recognize its own species, and thus the meeting of the sexes be facilitated. It must be remembered that many deep-sea crustaceans have excellent eyes. In short, these brilliant colors in all groups can, according to this theory, be explained by reference to the same laws that prevail on land or in shallow water.

Beddard regards as a fatal objection to this theory the fact that the eyes of many deep-sea dwellers are apparently now in the process of degradation. But the same thing is found among the mud-dwelling mollusca and the sponge-inhabiting crustacea, such as *Alpheus* in shallow water. Mud and sponges are also found in deep water and have their inhabitants as well. Again there are doubtless vast areas in which the phosphorescence is exceedingly feeble or entirely wanting, and yet they are not necessarily or even probably tenantless. In such places the possessors of eyes would find them worse than useless and gradual atrophy would ensue. I must confess to an utter inability to see the force of Beddard's so-called "fatal objection."

A side-light is thrown on our discussion by some of the well known facts concerning cave fauna. These facts are:

First.—Cave animals are almost universally colorless, or at least are not brightly colored.

Second.—I have been unable to find any record of phosphorescence among cave animals.

Third.—Blind animals are common in cave fauna.

Fourth.—No cave animals, so far as I know, are characterized by greatly enlarged eyes.

It would thus seem that the absence of phosphorescence in

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* Beddard explains such cases by saying that the parasite actually assimilates and deposits in its own skin the pigments of the host. (Loc. Cit., p. 38.) When we consider that the colors of the gorgonians are in the hard and jagged *spicules alone* we cannot withhold our sympathy from the ophiurian, which has either to eat such unattractive fare or in some way to absorb it through the skin.

caves has rendered both brilliant colors and large eyes useless, and thus both have been rigidly suppressed.

The presence of phosphorescence in so many animals which are supposed to be sightless, *e. g.*, pennatulids, gorgonians and hydroids, is hard to explain.* Indeed, it is not properly within the scope of this paper to explain it. A suggestion occurs to me, however, that may be worth noting. These animals feed, for the most part, on minute crustacea and on protozoa. Most crustacea, and more particularly *their embryos*, have functional eyes. *May they not be attracted by light*, as is the case with shallow-water forms? The protozoa are generally without distinct organs of vision, but many of them are, nevertheless, apparently attracted by light. If this is true, we have a reason for phosphorescence among the fixed cœlenterates. It attracts the prey. This, to my mind, is more plausible than the theory that it is a protective contrivance.

We may thus imagine the bottom of the sea to be for the most part dark, but with limited areas where are congregated phosphorescent animals that give forth sufficient illumination to render striking colors, particularly red, yellow and green, distinctly visible, enabling them to play the same role that they do in shallow water, and bringing them within the province of the same laws.

NOTES ON THE HEMIPTERA OF NORTHWESTERN IOWA.

BY HERBERT OSBORN.

From the difference in geological and floral conditions of the northwestern part of the state, we might naturally expect a somewhat interesting insect fauna. Occasional specimens of species, rare or unknown in the central part of the state, have come to hand and, especially in Hemiptera, have served to strengthen a desire to investigate more thoroughly the fauna in this order. Many of these additions have been due to the

* Verrill thinks that phosphorescence in these cases is of value in warning away enemies from the nettling cells. I have been unable to find nematocysts among the gorgonidæ and have never seen them mentioned as found among pennatulids. They are seldom of large size among the hydroids.

successful collecting of Mr. E. D. Ball, whose faithful, persistent efforts it is a pleasure to acknowledge here. During the summer of 1897 I spent a couple of weeks in the northwestern counties, primarily in the investigation of Hessian fly injuries, but availing myself of such opportunities as presented to collect the Hemiptera, and such collections at Rock Rapids, Little Rock, Storm Lake, Alta, Cherokee and Sioux City, in Iowa, and Sioux Falls, S. D., by myself, and at Little Rock by Mr. Ball, who gave especial attention to the jassidæ of the prairie grasses, furnish a basis for the preliminary consideration of the hemipterous fauna of the region.

It will be noted that nearly all the localities cited belong to the western slope and most of them to the formation peculiar to the Missouri valley. Little Rock is the most distant from the river, but its elevation and the numerous hills and ridges in the vicinity, bearing the sparse vegetation characteristic of the plains farther west, makes it faunally related to the more western localities. The lower levels and river valleys in all these localities present a fauna more like that of the rest of the state, as will be seen by comparison of complete lists, but the portion discussed particularly here is the part that belongs really to the plains region and which is extended into this area because of the conditions prevailing on the more elevated portions.

Much more attention was given to jassidæ than other groups, hence the great preponderance in this family. However, for the region and the vegetation worked, this is a natural preponderence.

HETEROPTERA.

Homæmus bijugis Uhl., is an abundant species in the region, occuring in rank vegetation of lower levels, and while ranging eastward and in some cases becoming fairly common, it appears to be more particularly typical of the plains.

Liodermа belfragii Stal., reported in the last proceedings, has not been obtained in Iowa in any other point than Little Rock. Stal. gives its habitat as "America borealis, Illinois."

Peribalus piceus Dall. Two specimens of this species from Little Rock are the only representatives taken in Iowa. They belong to the boreal fauna, and it is worthy of mention that the only part of Iowa touched by the transition zone, according to Merriam, is the northwestern corner, where these occurred.

Mecidia longula Stal. A single specimen of this southern species was taken at Sioux City from the crest of one of the hills. I know of no previous record for this species above the lower austral zone, but the Missouri valley doubtless furnishes conditions more nearly like the south and provides for the northern extension of such species. With this as an indication, we should hardly be surprised if *Murgantia histronica* were to appear in similar localities.

Chariesterus antennator Fab., another southern species belonging properly to the lower austral zone, was taken at same time and place as *Mecidia longula.* No other record of its occurrence in Iowa.

Harmostes reflexulus Say. Little Rock (Ball).

Pamera vicina Dall. (?) A species of Pamera which is tentatively referred here occurred in considerable abundance at Little Rock.

Palococoris suavis Reut. (?) Sioux City. Brachypterous form. Described from Texas.

Systratiotus americanus Reut. Little Rock (Ball).

Largidea opaca Uhl. This species is represented by a variety.

Mimoceps gracilis Uhl. This handsome species was taken at Little Rock, July 2d.

Of the plains fauna, and belonging to the upper austral, we have such species as Homæmus bijujus, Thyanta custator, Nysius californicus, Phelpsius altus, decorus, Driatura robusta, gammaroidea, Dorycephalus vanduzei, Deltocephalus collinus, albidus, reflexus, pectinatus, signatifrons, cruciatus, inflatus, Athsanus punctatus, Lonatura catalina, Agallia uhleri, Gypona cinerea.

Of boreal forms we have Peribalus piceus, Lioderma belfragei; of lower austral forms, Mecidia longula, Chariesterus antennator.

It does not follow that species not taken in the region do not occur there, as collecting through the season and in several seasons would be necessary to reach this point, but the group has been collected so thoroughly at Ames that we may be pretty sure that species found in the northwestern part of the state, and not at Ames, are not distributed over the central and eastern part of the state, and represent, therefore, a different fauna.

While such a survey must necessarily be considered preliminary, and the excuse for its presentation the probability that

only such fragmentary collecting, if any, can be done for many years, still we seem warranted in concluding

First.—That the region west of the divide supports numerous species which belong to the plains fauna of Nebraska and the Dakotas, and reach their eastern limit in the corner of Iowa.

Second.—That southern forms extend farther northward in the Missouri valley than in central Iowa, and

Third.—That the extreme northern portion includes some of the species of the boreal zone not observed elsewhere in Iowa.

SIOUX CITY.

Hecalus lineatus, Paramesus twiningi, P. vitellinus, Deltocephalus pectinatus, D. compactus, D. cruciatus, D. inflatus, D. nigrifrons, D. melscheimeri, Lonatura catalina, Driotura robusta, D. gammaroidea, Eutettix strobi, Chlorotettix spatulata, Phlepsius truncatus, P. altus, Gnatodus abdominalis, Macropsis apicalis, Agallia sanguinolenta, A. uhleri, A. cinerea.

Chariesterus antennator, Mecidia longula, Perillus circumcinctus, Palacocoris suavis, Reut?

LITTLE ROCK.

Dorycephalus vanduzei, Paramesus vitellinus, Neocoelidia tumidifrons, Deltocephalus pectinatus, D. albidus, D. reflexus, D. signatifrons, D. cruciatus, D. oculatus, D. melscheimeri, D. inflatus, D. configuratus, D. argenteola, D. collinus, D. inimicus, Lonatura catalina, L. megalopa, Driotura robusta, D. gammaroidea, Thamnotettix smithi, T. ciliata, Chlorotettix spatulata, C. unicolor, Phlepsius lobatus, Athysanus striatulus, A. magnus, A. comma, A. colon, A. punctatus, Cicadula 6-notata, Parabolocratis viridis, Idiocerus duzei, Macropsis apicalis, Pediopsis viridis, Agallia sanguinolenta, A. cinerea, A. novella, Philænus bilineatus.

Systratiotus americana, Mimoceps gracilis, Largidea opaca (var.) Phytocoris sp. Harmostes reflexulus.

CHEROKEE.

Hecalus lineatus, Deltocephalus pectinatus, D. argenteola, D. inimicus, D. oculatus, D. melscheimeri, Chlorotettix spatulata, C. unicolor, Athysanus striatulus, A. comma, A. colon, Phlepsius altus, Parabolocratis viridis.

ROCK RAPIDS.

Deltocephalus nigrifrons, D. sayi, D. inimicus, Athysanus comma, Cicadula 6 notata, C. variata.

SIOUX FALLS, S. D.

Paramesus vitellinus, Neocoelidia tumidifrons, Deltocephalus inflatus, Phlepsius decorus.

YANKTON, S. D.

Neocoelidia tumidifrons, Deltocephalus pectinatus, D. nigrifrons, Platymetopius sp., Chlorotettix spatulata, C. unicolor, Athysanus striatulus, A. comma, Cicadula 6-notata, Gnathodus abdominalis.

A GENERIC SYNOPSIS OF THE NEARCTIC PENTATOMIDAE.

BY H. E. SUMMERS.

Practically the only keys for determining the genera of our Pentatomidæ are those of Stål. These cover only certain divisions of the family, and even in these divisions many recently established genera are not included. His works are, moreover, usually not accessible except to the special student of the Heteroptera, and even when accessible, the fact that they deal with a fauna much more extended than our own, makes them too cumbersome for the ready use of the general student. For these reasons it is thought that a key limited to our fauna and brought up to date may be a convenience.

For the chief groups the classification of Stål, followed in the main by Uhler in this country, has been adopted, although the present writer has grave doubts of the natural character of some of the divisions. In consequence of the introduction of new genera it has been found necessary to modify considerably Stål's definitions of some of the groups. All the recorded Nearctic genera have been examined. Thanks are due Dr. S. A. Forbes for placing freely at my disposal the material of the Illinois State Laboratory of Natural History, and to Mr. E. D. Ball, of the Colorado State College of Agriculture, for the loan of specimens.

TABLE OF SUB-FAMILIES AND GENERA.

A. Tarsi 3-jointed.

B. Bucculæ converging caudad, caudal ends united; basal segment of rostrum thickened. (Sub-family *Asopinæ.*)

C. Pre-femora armed with a spine or acute tubercle below.

D. Scutellum large, broad, extending almost or quite to apex of abdomen; frena never extending more than a third the length of scutellum.

Stiretrus.

DD. Scutellum medium; frena extending to the middle of scutellum. *Perillus.*

CC. Pre-femora unarmed.

D. Base of venter distinctly armed with a somewhat prominent spine or acute tubercle extending cephalad.

E. Bucculæ very slightly elevated, gradually disappearing caudad; frena extending distinctly beyond middle of scutellum. *Podisus.*

EE. Bucculæ distinctly elevated, not at all thinning out caudad, joining at caudal ends; frena extending just to middle of scutellum. *Mineus.*

DD. Base of second segment of venter unarmed, sometimes elevated into a small obtuse tubercle not projecting at all cephalad.

E. Segment 2 of rostrum as long as the two apical segments together.

F. Juga scarcely longer than tylus; body, at least thorax, shiny. *Euthyrhynchus.*

FF. Juga longer than tylus; body not shiny. *Rhacognathus.*

EE. Segment 2 of rostrum shorter than segments 3 and 4 together.

F. Juga longer than, and meeting in front of, tylus; body not shiny. *Dendrocoris.*

FF. Juga scarcely longer than tylus; body shiny. *Zicrona.*

BB. Bucculæ parallel, not united caudad; basal segment of rostrum usually slender, rarely very slightly thickened. (Sub-family *Pentatominæ.*)

C. Scutellum large, broad at apex, extending farther caudad than corium, usually reaching apex of abdomen; sides of pronotum with a prominent tooth just cephalad of lateral angle. (Tribe *Podoparia.*)

D. Juga longer than tylus, but not contiguous cephalad of it; head considerably narrower in front than between eyes; pronotum about one-third longer than head. *Podops.*

DD. Juga contiguous cephalad of tylus; head nearly as broad in front as between eyes, but little shorter than pronotum. *Oncozygia.*

CC. Scutellum rarely extending farther caudad than corium, in that case sides of pronotum always entire near lateral angle.

D. Jugum with a prominent lateral tooth near apex, or with apex pointed and projecting far cephalad of tylus; sides of head not distinctly sinuate just cephalad of eyes, antennal tubercles visible from above, and eyes placed close to cephalic angles of pronotum. (Tribe *Halyaria.*)

E. Jugum with lateral tooth near apex; antennal segment 2 cylindrical, shorter than segment 3; venter with shallow mesal sulcus; body rather broad. *Brochymena.*

EE Jugum without lateral tooth, somewhat pointed at apex, projecting far cephalad of tylus; antennal segment 2 triangular, longer than segment 3; venter without sulcus; body elongate. *Mecidea.*

DD. Jugum without lateral tooth; apex usually rounded, rarely pointed, in that case not projecting cephalad of tylus; sides of head usually distinctly sinuate near eyes, sometimes almost straight, in that case either antennal tubercles not at all visible from above or the eyes quite distant from cephalic angles of pronotum.

E. Head triangular, very convex on dorsal surface, not less than seven-eighths as broad as scutellum; juga distinctly longer than tylus; apex of corium broadly rounded.

(Tribe *Aeliaria.*)

F. Pronotum with three longitudinal low ridges; cephalic angles of pronotum projecting conspicuously cephalad. *Aelia.*

FF. Pronotum with a single (mesal) longitudinal ridge; cephalic angles of pronotum not projecting cephalad. *Neottiglossa.*

EE. Head of various forms, usually only slightly convex on dorsal surface, less than seven-eighths as broad as scutellum; juga usually no longer than tylus, and apex of corium with a distinct though usually somewhat

rounded lateral angle; rarely juga longer than tylus or apex of corium broadly rounded, in either case the head only about two-thirds as wide as scutellum. (Tribe *Pentatomaria.*)

F. Segment 2 of venter unarmed, neither spinous nor tuberculate on meson.

G. Odoriferous orifices either far laterad of coxæ or distinctly elevated or continued in a sulcus; head more commonly not strongly bent ventrad, lateral margins of juga sometimes narrowly reflexed, reflexed portion never greatly swollen.

H. Scutellum with apex broad and rounded, lateral margin scarcely concave at any point; head bent strongly ventrad. *Cosmopepla.*

HH. Scutellum usually with apex distinctly narrowed and lateral margin concave toward apex; otherwise the head little or only moderately bent ventrad.

I. Odoriferous orifices either without a sulcus, or with a sulcus ending suddenly, not continuing into a gradually disappearing wrinkle.

J. Veins of membrane irregularly anastomosing or irregularly furcate or ramose.

K. Lateral margin of pronotum entire, unarmed; lateral angle rounded, not at all produced.

L. Scutellum broadly rounded at apex, as long or nearly as long as corium; apical margin of corium rounded, apical angle obtuse. *Coenus.*

LL. Scutellum narrowed at apex, not extending so far caudad as corium;

apical margin of corium nearly straight; apical angle acute.

M. Bucculæ increasing in height caudad, ending abruptly; lateral margin of pronotum not explanate; frena reaching just to middle of scutellum; rostrum extending a little caudad of medicoxæ. *Hymenarcys.*

MM. Bucculæ elevated into an angle at cephalic end, less elevated caudad; lateral margin of pronotum explanate cephalad; frena reaching beyond middle of scutellum; rostrum extending caudad of post-coxæ. *Menecles.*

KK. Lateral angles of pronotum produced into a conspicuous spine. *Proxys*

JJ. Veins of membrane simple or slightly furcate.

K. Frena extending beyond middle of scutellum.

L. Tibiæ all terete, without sulcus.

M. Joint 1 of rostrum extending a little beyond bucculæ. *Mormidea.*

MM. Joint 1 of rostrum shorter than bucculæ. *Oebalus.*

LL. Tibiæ sulcate above.

M. Cephalic part of lateral margins of pronotum crenulate, lateral angles prominent, either rounded or pointed; head, including eyes, not distinctly wider than long. *Euschistus.*

MM. Lateral margins of pronotum entire, lateral angles rounded, not prominent; head, including eyes, distinctly wider than long. *Chlorochroa.*

KK. Frena not extending beyond middle of scutellum.

L. Lateral margins of pronotum with a prominent process slightly bent caudad at lateral angles. *Prionosoma.*

LL. Lateral margins of pronotum entire, lateral angles rounded.

M. Dorsal surface with coarse, black punctures, irregularly arranged especially on the pronotum. *Trichopepla.*

MM. Dorsal surface with finer regularly arranged punctures. *Carpocoris.*

II. Sulcus from odoriferous orifices continued laterad in a gradually disappearing wrinkle.

J. Juga not longer than tylus. *Thyanta.*

JJ. Juga longer than tylus, contiguous at their cephalic ends.

K. Apical margin of corium uniformly convex; lateral margin of head very slightly sinuate cephalad of eyes. *Peribalus.*

KK. Apical margin of corium very slightly sinuate near lateral end; lateral margin of head distinctly sinuate cephalad of eyes. *Holcostethus.*

GG. Odoriferous orifices situate just cephalad of lateral border of post-coxæ, without sulcus, scarcely elevated; head strongly bent ventrad, front almost vertical; reflexed lateral margins of juga much swollen. *Murgantia.*

FF. Segment 2 of venter with a mesal spine or tubercle pointed cephalad.

G. Metasternum little elevated, never with a bi-lobed process extending cephalad of medi-coxæ.

H. Segment 5 of antennæ less than twice as long as segment 2; scutellum and pronotum nearly or quite concolorous. *Nezara.*

HH. Segment 5 of antennæ more than twice as long as segment 2; apex of scutellum and cephalic half of pronotum much lighter in color than remaining portions. *Banasa.*

GG. Metasternum strongly elevated, produced far cephalad between the medi-coxæ into a bi-lobed process. *Edessa.*

AA. Tarsi 2 jointed (sub-family *Acanthosominæ*). *Acanthosoma.*

PRELIMINARY REPORT ON THE DIATOMS OF IOWA.

BY P. C. MYERS.

Within the last two years the author has often had occasion to congratulate himself for having acted on a suggestion from Prof. B. Shimek, of the State University of Iowa, to take up the study of a group of organisms which hitherto had, from the botanists of this state, received but scant attention.

The diatomaceæ constitute a group of microscopic organisms hovering near the place of meeting, if such there be, of plants and animals. Their closest affinities, however, seem to be with the plants.

Unicellular though they be, they make for themselves a glassy covering, whose two parts fit together as the top and bottom of a pill box. Chlorophyl is present, which, however, is masked by a brown coloring material called diatomin. Nearly all these little organisms have the power of movement; a graceful, gliding motion that reminds one of little steamboats.

Their study is connected with considerable difficulty, which probably accounts for their being neglected.

First.—They must be collected, a not o'er easy task.

Second.—They must be cleaned, in which not less than seven separate and distinct operations are necessary; some of these are boiling in nitric acid, immersion in potassium permanganate for three or four days, boiling in hydrochloric acid and a deal of washing.

Third.—They must be mounted, one at a time, on separate slides. As these little objects range in size from one-fiftieth of an inch, in the largest, to one-two-thousand-five-hundred-fortieth part of an inch in the smallest, it cannot be said to be heavy work, but it requires considerable concentration of the attention.

Fourth.—They must be identified. As the literature is badly scattered, one cannot hope to do much without several expensive sets of books and pamphlets. Even then there is a little

truth in the remark made by another botanist, with a sniff, that you might as well try to classify wall paper. The difficulty, however, is not greater than in other orders of equal size.

At first it might appear that the state of Iowa, with its monotonous rolling prairies would offer little diversity of aquatic plant life, but this has not proved to be the case. For present purposes the various localities where diatoms are found may be grouped in four divisions.

First.—Creeks and rivers, with the bogs and old river channels connected with them.

Second.—Springs, with the bogs and ditches watered by them.

Third.—The lakes found in that portion of the state covered by the Wisconsin drift.

Fourth.—Fossil deposits.

The first localities named, the creeks and rivers, were the first from which material was collected. Here abound the smaller naviculæ, synedræ, melosiræ, and most abundant of them all, the gomphonemæ, which may be seen as long, gelatinous streamers of a rich brown color, in moving water, or as a covering on the stones in rapids and cataracts. In the brooks and ditches the more fragile forms of nitzschia and synedra are found. Under favorable conditions these little organisms cover the bottom of the brooks and ditches to a depth sufficient to color everything a rich brown. When the sun shines on them the oxygen liberated raises them to the surface of the water and they are carried along until they strike a twig or board or other obstacle, where they may be seen at times an inch in depth and several square feet in extent.

East of Iowa City, about two and one-half miles, there is a prairie slough, having in it at one point a broad and shallow basin, where the water stands a greater portion of the year. In the month of June this presents to the diatomist at least, a most remarkable appearance. In this basin, covering an extent of about an acre, and to the depth of eight or twelve inches, is a flocculent seal brown mass of living diatoms. Here *Fragillaria virescens* stretches its tiny ribbons, and *Meridion intermedium* spreads its miniature fans in numbers innumerable.

In the northern portion of the state, where the rivers are but little more than motionless lagoons, the amount of aquatic material is indeed prodigious. In such quantities do algæ,

lemnas, potomagetons, wolfia and diatoms grow, that the river is literally choked from bank to bank.

In the northeast corner of the state, however, the conditions are altogether different. The drainage system there is anything but poorly developed, it being a part of the state not known to have been glaciated. Many forms of diatoms are found here, not common to other localities in the state.

The Missouri river and its immediate tributaries offer but little that is interesting to the diatomist. But few species are found here, as the rapid currents and ever changing banks and beds of mud do not permit of their gaining a lodgment.

The second group of localities, the springs and bogs, offer us a flora at once more varied and robust. Here are found the larger naviculæ, with *Suriraya splendida*, *Campylodiscus spiralis*, *Stauroneis phoenecenteron* and a host of others, all with frustules strongly silicified. In a little bog, fed by a spring, some four miles from Iowa City, in a place but six feet square, the species *Campylodiscus spiralis*, a very large and pretty diatom, occurs in large numbers, its only known locality in the state, except, perhaps, one on the Des Moines river near High Bridge.

The third group of localities, the lakes in that portion of the state covered by Wisconsin drift, presents features of more than usual interest.

Clear Lake, located in Cerro Gordo county, is about six miles long by three wide. It belongs to the class of "kettle holes," and lies on the eastern edge of the Wisconsin drift, occupying the highest ground in that region. The town of Clear Lake has an altitude above sea level of 1,238 feet, while at Mason City, nine miles east of there, the altitude is only 1,128 feet, or 110 feet lower. On the north, west, and south much the same conditions prevail.

This falling away in all directions brings about the following results:

First.—Very little surface drainage; the slope toward the lake being, in some places, only a few feet, while on the west it reaches its greatest length of about one mile.

Second.—There is no overflow, a state of equilibrium existing between rainfall and evaporation. Here, then, are the conditions necessary for the deposition of a bed of organic material. On examination the lake showed the following conditions:

The entire bottom, except a narrow strip along the shore

where the undertow keeps it clean, is covered with a bluish-black material, light of weight and very soft and yielding, commonly called mud. This is everywhere underlain by a heavy, tenacious, gravelly, blue clay. In the west end of the lake, at what is called the rice beds, where the water is only about two feet deep, the aforesaid mud reaches a depth of eighteen feet. Near the center of the lake are the "moss beds," with the water three feet deep and a deposit of twenty-one feet. About midway between the "moss beds" and the eastern shore the water reaches its maximum depth of fifteen feet, with the depth of the deposit undetermined.

On examination this deposited material proves to be 75 per cent organic matter, 12½ per cent fine sand and 12½ per cent diatom frustules. On an average this would give us a bed of diatoms two and one-half feet thick over an area of eight or ten square miles.

The number of species found in this material will number sixty, among them some of the largest and most beautiful fresh water forms known, such as *Suriraya robusta* and *biseriata*, *Navicula nobilis* and *peregrina*, *Cymatopleura solea* and *elliptica*. Here, too, are found *Nitzschia sigmoidea*, 400 to 500 micra long, with its 66,000 striæ to the inch, and *Nitzschia palea* with 91,440 striæ to the inch.

The species and individuals both decrease in numbers as one passes downward, *i. e.*, there are more diatoms growing there now than at any previous time. The increase in species has most likely been accomplished by waterfowl carrying hither bits of mud from other lakes.

One feature of the Clear Lake diatoms was very puzzling. What appeared to be *Pleurosigma attenuatum*, which usually has a length of 190 to 250 micra, was habitually 250 to 300 micra long. *Cymbella ehrenbergii* presented the same variation, as did likewise half a dozen other species. This variation toward larger forms came, finally, to be so common an occurrence that it was concluded that it perhaps was due to an extraordinary amount of silica in solution, and other very favorable conditions.

Spirit Lake is located in Dickinson county, Iowa, on the western part of the Wisconsin drift. It resembles Clear Lake in most essential points. The sand beach, however, is wider, and it is not so rich in microscopic forms. The deposit is not so great, but the water somewhat deeper.

East Okoboji Lake is composed of three small lakes in a chain, the water varying from three feet in the upper one to eighteen or twenty feet in the lower one. The deposit varies also from eight feet in the upper to a much greater depth in the lower. Here there is a much greater percentage of sand than in Clear Lake, due to more extended surface drainage and steeper hills.

The channel, however, which connects East Okiboji and West Okiboji Lakes, is the most remarkable place of all. Remarkable, not only for the number of diatoms, but for a host of other aquatic forms growing in the most lavish profusion. The conditions here are certainly very favorable for plant growth. High hills, covered with trees, protect the channel from the winds, and its form precludes the possibility of large waves. Then, too, a gentle current sets from one lake to the other, keeping the water in fine condition. In the fall, after the larger plants have passed their perfection and have begun to die, the diatoms overrun them all and, indeed, every other thing below the surface of the water. The common bladderwort becomes the home of vast colonies of the stalked forms, as cocconema, gonphonema, bands of fragillaria, with long, acicular synedra intermingled. Acres are thus covered, where there are no large waves and the water is not too deep. In those parts of the lake where rushes grow, each one is covered below the water line with a layer a half an inch or more in thickness.

Across this channel a railroad was built, and in so doing a diatomaceous deposit was found fifty-two feet deep

In West Okiboji Lake water was found 125 feet deep, the deposit being of unknown depth. So soft and yielding is this material that a dredge, weighing only two or three pounds, when dragged along the bottom sinks into it to a depth of ten or twelve feet.

In comparing the species found here with those found in Clear Lake, both lying in the same geological formation and no great distance apart, it is seen at a glance that they are utterly different. In Clear Lake such genera as suriraya, navicula, cymbella, eunotia pleurosigma and cymatopleura are found, as compared with cocconema, odontidium, stictodiscus and synedra in Okoboji Lake.

Silver Lake also adds a small quota, but has not been carefully examined.

The fourth division, that of fossil diatoms in Iowa, is reserved for another paper.

The number of counties in the state which have been visited by the author, and those from which material has been received, number twenty-nine.* At some future time we expect to present to the people of Iowa who are interested in this work, a descriptive list of all the species of diatoms found, with a photograph of each.

REPORT ON A FOSSIL DIATOMACEOUS DEPOSIT IN MUSCATINE COUNTY, IOWA

BY P. C. MYERS.

Previous to the present year no fossil diatoms had been found in Iowa. On October 20, 1898, Prof. J. A. Udden, of Rock Island, Ill., while engaged in work for the Iowa Geological survey, found and sent to Prof. S. Calvin, of the State University, some diatomaceous earth. This material was taken from below the loess in Muscatine county, Iowa, and was turned over to the author for examination. It was of a dull, yellow color, composed of sand and decayed vegetable matter and a few diatoms.

The species, with their general distribution and habitat, are as follows:

Navicula abaujenssis Paut. Fresh water fossil in Hungary.

Navicula borealis (Ehr.) Kuetz. In fresh water, cataracts, rivers and wet moss, all over Europe and America.

Navicula gibba (Ehr.) Kuetz. Everywhere in fresh water.

Navicula major Kuetz. A cosmopolitan species in fresh water.

Navicula nobilis (Ehr.) Kuetz., var. dactylus (Ehr.) V. H. In bogs and fossil.

Navicula rupestris (Pinn.) Hantz. On wet rocks.

Navicula placentula (Ehr.) Kuetz. In rivers in Europe and America; also fossil and marine.

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*As there are many places in the state still unexplored, I desire at this time to say to the members of the Academy that I should be glad of their co-operation in this matter.

Eunotia diodon (Ehr.). Rivers, springs, rapids, on wet rocks and fossil.

Eunotia gracilis (Ehr.) Rabeuh. In boggy, swampy places.

Eunotia major (Wm. Sm.) Rabeuh. In fresh water everywhere.

Stauroners phoenecemteron (Nitz.) Ehr. Cosmopolitan.

Cystopleura gibba (Ehr.) Kunze. Common in fresh water; also fossil and marine.

Cymbella cymbiformis (Kuetz.) Breb., var. parva (Wm. Sm.) V. H. Common everywhere in fresh water.

Hantzschia amphyoxis (Ehr.) Grun. Common everywhere in fresh water.

Judging from the above and from evidence which does not appear here, *i. e.*, the comparative number of individuals in each species, the condition was probably that of a shallow bog, subject to gentle overflows from some creek or river.

DIATOMACEOUS EARTH IN MUSCATINE COUNTY.

BY J. A. UDDEN.

While at work on the geology of Muscatine county last summer, the writer found some diatomaceous earth in the south bank of the creek which runs west near the south line of section fourteen, in Cedar township. It is associated with a peaty layer, which overlies it, and which appears somewhat disturbed. This peat is overlain by fine laminated sand and silt, which here forms the base of the loess. Below the peat bed and the diatomaceous layer there is a white sand without a trace of ferruginous stains. Boggy conditions are indicated, or perhaps the conditions of a lake or pond. The diatomaceous earth itself does not lie in a continuous layer, but in a broken layer, or in small pockets, which are scattered. It has a peculiar dull, pink color, and this has lately enabled the writer to find small lumps of it in the peaty soil under the loess in Scott county, near Davenport. It was from this loess that the remains of a mastodon have been reported by Mr. Pratt.

THE PINE CREEK CONGLOMERATE

BY J. A. UDDEN.

In the right bank of the west branch of Pine creek, a short distance north from where it leaves section thirty-four in range one west, township seventy-seven north, there is a pebbly sandstone, unlike the coal measure conglomerate in the surrounding country. This sandstone is mostly brown in color, changing to yellow. It has a rather coarse texture, compared with the coal measure rocks, and is somewhat more variable in this respect. The best exposure appears in a small gully, which comes down the hill from the west, some twenty rods north of the south line of the section. In all a thickness of about sixteen feet is seen. Springs issue from the base of this rock, along the slope to the creek, indicating finer impervious underlying beds. The lower part of the section has one ledge which is two feet in thickness. But the bedding is irregular and the layers vary much in thickness in short distances. Some of the ledges are strong enough to be used for building stone, while one or two are loose sand. Even the hardest layers break easily under the hammer. In these the sand and gravel is cemented by a black matrix of peroxide of iron. The uppermost ledges are somewhat finer than the lower. Two sets of quite regular joints here cut the rock. One set bears west of north and the other north of east. Along these joints the ferruginous material is most profusely deposited. Some of the ledges are cut up into rhomboidal blocks about a foot in length and from eight to ten inches in width. These have a shining black hard crust, half an inch or more in thickness, which on some of the blocks has separated from the lighter and softer rock within, forming thin, straight and smooth plates. Above this brown sandstone there is a yellow loose sand containing small boulders of greenstone and granite. On top of this sand there is boulder clay and loess. Small exposures of the conglomerate occur for a distance of a quarter of a mile along the west side of the creek to the south of this place.

The degree of induration, the pronounced jointing, and the general ancient aspect of this conglomerate render it reasonably certain that it is not a part of the drift which overl es it. But it has pebbles of Archæan rock, and one of these was nearly six inches in diameter. None of them were observed to be scored, though quite a number were examined. The average size of the pebbles is from one-fourth to two inches in diameter. On the other hand, it is not believed that it can belong to the coal measures. Some of the pebbles appear to be pieces of coal measure concretions and lumps of coal measure clay, and the aggregation of rocks represented in the pebbles is unlike anything observed in the coal measure conglomerate. For comparison, a collection of fifty pebbles was made, representing the average sizes. The proportion of specimens of different rocks in this lot was as follows:

Yellow chert	32 per cent
Greenstone	26 " "
Granite (mostlv red)	10 " "
White quartz (some of a faint, pink color)	8 " "
Fragments of coal measure rock	4 " "
Light red orthoclase	2 " "
Black felsite	2 " "
Porous Niagara chert	2 " "
Chalcedony	2 " "
Orthoclase-biotite rock	2 " "

The only conclusion which can at present be drawn, as to the age of this conglomerate, is that it is post-Carboniferous and preglacial. Dr. Calvin, who has seen it recently, pronounces it identical in nature to the Rockville conglomerate described by McGee. It also somewhat resembles the Cretaceous conglomerate found in Guthrie county by Mr. Bain. Possibly it may be an outlier of the Lafayette formation, observed farther south by McGee and by Salisbury.

In the south bluff of West Hill in Muscatine, just east of Broadway street, there lies on top of the coal measures and under the drift a small remnant of a conglomerate somewhat resembling that above described. It is seen for a distance of only three or four rods and its greatest thickness is three feet. It is plainly unconformable with the beds below. The base is a very pebbly sand, held in a dark ferruginous matrix, which, in some places, does not wholly fill the interstices between the pebbles. The upper surface is a brown ferruginous, moderately fine sandstone of about the same hardness and aspect as

the middle ledges in the Pine creek conglomerate. It is seen to contain three rounded boulders from eight inches to one foot in diameter. One of these consists of gneiss, one of mica schist and one of quartzite. In a collection of 100 pebbles from this ledge, different rocks were represented by the number of pebbles indicated in the following list:

Greenstone	26 per cent
White quartz	26 " "
Yellow chert	18 " "
Granite (mostly red)	7 " "
Light red orthoclase	5 " "
Coal measure rock	4 " "
Black felsite	3 " "
Quartz-biotite schist	3 " "
Faintly pinkish white quartz	2 " "
Quartz speckled with jasper	2 " "
Red quartzite	1 " "
Hornblende rock	1 " "
Milky quartz	1 " "
Gneiss	1 " "

The author is inclined to the opinion that this conglomerate in Muscatine and that exposed on Pine creek are both outliers of the same formation, but he has no suggestion to offer as to what age they really belong farther than as above stated.

FOREST TREES OF ADAIR COUNTY, IOWA.

BY JAMES E. GOW.

In order to understand the forestry conditions of Adair county, a short description of the lay of the land and the nature of the soil is first necessary. The county lies along the crest of the "grand divide," between the Mississippi and the Missouri, so that a line drawn along the crest of the ridge traverses it diagonally from northwest to southeast. The land is undulating enough to secure an easy natural drainage, but not so undulating as to be difficult of cultivation, except in a few isolated localities. The soil is a rich, black loam, varying in thickness from a few inches to ten or fifteen feet and underlain by a stiff, yellow clay. Here and there, the larger streams may be found flowing over beds of limestone, but as a rule

they flow either through the black surface soil or the yellow clay below it. Of these streams, North river and Middle river enter the Des Moines, while Grand river and the Nodaway flow into the Missouri. Although commonly called rivers, none of them attain to sufficient size, in Adair county, to deserve the name, but all become streams of considerable size before losing their identity in the Missouri or the Des Moines. The rivers along whose course is found the heaviest timber are Middle river and the west branch of the Middle Nodaway, and it is on these streams that the greatest variety of species have been found and most of the observations have been made The prairie in Adair county is practically bare. The only trees or bushes ever found upon it in any abundance are the hazel and bur oak, and these have been largely grubbed out and destroyed. The wild plum, wild cherry and American crab, may occasionally be found on the high prairie, but they very seldom, if ever, occur there unless protected by other low timber, and as the bur oak and hazel are destroyed, they vanish also. So it is along the streams that the student of forestry must seek his information.

Even a cursory examination of these streams is sufficient to show that, with few exceptions, the southern or western bank is steep and rough, while the northern or eastern bank is smooth aud rises with a gentle slope. Along most of the course of Middle river, through the county, the southwestern bank consists of steep clay bluffs, densely wooded and rising abruptly from the water, while the northeastern bank slopes up very gradually from the water—making a wide, level valley or bottom, which is usually either destitute of trees, or less heavily wooded than are the bluffs of the opposite bank. The same condition may be noticed quite generally with regard to the smaller streams. In driving along the road it is noticeable that the steepest hills face the north or east, and the gentler inclines the south or west. The reason for this must be that the erosion has been greater on the north than on the south bank, owing to the fact that the former receives the full rays of the spring sun, while the southern bluff lies in shadow most of the day. This, of course, would cause the snow and ice upon the northern slope to melt very quickly, making considerable erosion, while upon the southern bank it would melt much more slowly and hence cause much less erosion. Where the course of a stream is southward it is the left bank which

shows the greater signs of erosion, because it is exposed to the burning rays of the afternoon sun, while the right bank is in shadow during the hottest part of the day. The effect of this process upon the distribution of timber is evident. The steep bluff-land upon the southern or western bank of a stream is usually heavily wooded, while the flat "bottom" upon the northern or eastern side is often very sparsely covered with trees and sometimes quite bare. Before the advent of civilization the southern bluffs often held the moisture of the winter snows and spring rains until after the season of prairie fires, thus giving the trees sprouting upon their surface a chance to grow, and, when the trees had grown large enough, they further protected themselves from fire, the surrounding grass being killed out. But the northern bank, which had to face the rays of the spring sun, was well dried by the time the grass on the prairie was dry enough to burn, and so the trees growing upon its surface were destroyed. This is the process which must have taken place during many years before the day when the plow of the first white settler cut the soil of western Iowa. Its effects are still noticeable, but not so noticeable as they must have been at an earlier day. To-day, practically all of the trees in Adair county are of second growth. There are left only a few isolated specimens of the so-called first-growth timber. Since the days when the prairie fires ceased, seedlings have taken root in the fertile flats which form the northern and eastern banks of our streams, and have grown into trees of goodly size, and in some places the southern bluffs have been shorn of their trees. Still, in a general way, the primitive condition is still noticeable; the timber on the southern bluff is usually larger and thicker than that on the northern bottom. It is noticeable, too, on the prairie—wherever enough of the original brush has been left to indicate anything at all. The hazel and bur oak will grow on a southern or western slope, but they are not generally found in such a situation. Usually they seek the northeastern side of a hill, and there they flourish luxuriantly.

As has been said, there is very little of the first-growth timber remaining in Adair county. The first settlers of the county found along the streams a thick growth of large, well developed trees. Since then almost all of these trees have been removed, until there remains very little timber which was well grown at the time of the first settlement of the county,

forty years ago. In its place has appeared a growth of smaller trees, which were saplings when the older trees were destroyed, or have grown from the seed since that time. Here and there may be seen a relic of the first growth—some giant of the forest who towers high above all the trees about him—but, as a rule, the forest of to-day is made up of younger and smaller trees than those which composed the forest of forty years ago.

The area, however, of the timber land along the streams remains about what it was at an earlier day. It may possibly be a trifle less, but only a trifle. The second growth covers substantially the same area that was covered by the first growth. The chief denudation of the country has come about, not through the destruction of the larger trees which grow along the rivers, but through the removal of the bur oak, hazel, and other prairie species. Before the settlement of the county—if we may trust the accounts of the earliest settlers—a large part of the prairie was covered with brush. To-day the greater part of the brush is gone and the land upon which it grew is under cultivation. The absence of the brush from the prairie tends to increase erosion and decrease the conservation of moisture in the soil, but its destruction was inevitable because necessary to the successful carrying on of agriculture; and, as conditions grow harder and the land becomes more densely populated and more closely farmed, the destruction of that which is left will become necessary and inevitable. But as the prairie brush is destroyed greater care than ever should be taken to preserve the large and really valuable timber along the rivers, and to extend its area if possible. The people of Adair county have not carelessly destroyed their forests as have the people of many portions of the country. They have preserved them, but it cannot be said that they have preserved them understandingly. The second growth has come in so thick in many places as to choke itself. Valuable walnut, ash or hickory trees are often prevented from making a good growth by the thickets of maple, elm or elder in which they grow, and, too often, when the needs of the farmer force him to cut firewood for himself, he takes all the trees from a certain area, instead of cutting out only those which can best be spared and leaving the remainder. A little popular education on the subject of forestry might remedy these difficulties and teach our farmers to take a greater interest in their forests and better care of them.

During the past twenty-five or thirty years the extent of artificial groves in Adair county has grown from nothing at all to many acres. Almost every farm-house now has a yard full of trees and a wind-break to the north, and hedges of maple, willow and osage orange line many of the roads. Unfortunately, the best species for the purpose are seldom used in these groves. Instead of planting walnut, ash or white oak, our farmers usually plant the soft maple, on account of its rapid growth, and the result is that no sooner do the trees arrive at a respectable size than the winds play havoc with them. The box elder is much used, more on lawns, however, than in groves, and although rather soft it is a good tree and a very pretty one when properly trimmed. The willow figures occasionally in groves, but more frequently in hedges on low lands, where the maple is also sometimes used. Groves of walnut or of ash are occasionally met with, but are not common. The cottonwood is used but rarely and the oak never, so far as we know. While these artificial groves are of little value in conserving moisture, preventing erosion and preserving true forest conditions, they are useful in breaking the force of the winter winds, and they exert more or less of a civilizing influence by adding to the beauty of the monotonous prairie landscape and the comfort of life on the farm.

In Adair county a few species of trees, which are common elsewhere in Iowa, are conspicuous for their absence. The butternut, sycamore and hard maple are found in Madison county, along the course of the Middle river, but we have been unable to discover that a single specimen has ever been found growing wild on this side of the line. The Missouri hickory grows along the Nodaway, it is said, north of the state line, but does not extend this far north. The pawpaw is found occasionally in southern Iowa, but has not been found in Adair county. The fact of a few birch trees having been observed, some twenty years ago, near the town of Casey, on the north line of the county, led to a search through that locality, but no birches were found and none have been found in any part of the county. Both the butternut and birch are reported as being common along the course of the North Raccoon river in Guthrie county.

Following is a list of the species of forest trees found growing in Adair county. The nomenclature of Wood has been followed throughout:

Ulmus americana L. White elm. Common on banks of streams and in valleys, sometimes growing a little way up the sides of bluffs and occasionally found on upland. Attains its greatest size on low ground. Well distributed throughout the county. Frequently planted as a shade tree

Ulmus fulva L. Red elm. Slippery elm. Found only on low land. Common. A smaller species than the preceding.

Ulmus racemosa Thomas. Rock elm. A rare species which we have not found within the county. Has been reported by an early settler, well acquainted with the native timber, as growing in scattered locations along the west branch of the Middle Nodaway.

Quercus macrocarpa Michx. Bur oak. Scrub oak. This species is very common and occurs most frequently on the sides and summits of river bluffs and on the high prairie, where it is a gnarled, stunted, shrubby tree, varying in height from ten to twenty feet. Occasionally, however, it may be found growing in rich river bottoms, where it becomes much straighter, resembling the white oak in its habit of growth and attaining a height of thirty or forty feet. It is the most abundant species of oak and one of the most abundant trees in Adair county. On the prairie it and the hazel appear to be inseparable companions. The bur oak is almost the only tree which safely resisted the prairie fires and grew in abundance on the open prairie, before the advent of civilization. Clumps of it are found scattered over the prairie at intervals—remnants, evidently, of the more abundant growth which once covered the country.

Quercus rubra L. Red oak. A handsome, straight tree, found in tolerable abundance on the bluffs near the larger streams and occasionally on bottom land or in thickets of bur oak on the high prairie.

Quercus alba L. White oak. Not uncommon. Found along the larger streams—seldom, if ever, on prairie. Prefers rough, clay bluffs.

Quercus coccinea var. *tinctoria* Wang. Black oak. Not so abundant as the red oak and occupies the same habitat. Does not attain the size of either of the preceding species.

Negundo aceroides Moench. Box elder. This is probably the most common of all the trees native to Adair county. It is found along all the streams wherever there is any timber at all and is often planted on lawns and in groves on the prairie, where it flourishes.

Acer rubrum L. Red maple. Soft maple. Swamp maple. Quite common. Grows luxuriantly on the banks of streams and in all low, moist places. Very frequently planted in groves and on lawns, where its soft wood is often broken by high winds which it is unable to resist without the protection of larger timber.

Carya alba N. Shell-bark hickory. Common along the larger streams, where it grows well up on the bluffs, and occasionally in the bottoms.

Carya glabra Torr. Pig nut. A somewhat smaller and coarser species than the preceding. Usually found on lower land. The two species are about equally common.

Juglans nigra L. Walnut. Common along the larger streams, where it grows luxuriantly and attains a good height. Never seen on the prairie, except when planted there, which is not often the case. The walnut was much more abundant a quarter of a century ago than it is to-day, although it is still a very common tree. Owing to the value of the wood it has probably suffered more at the hands of woodmen than has any other tree found in Adair county.

Tilia americana L. Basswood. Linden. Quite common in all river bottoms. Seldom seen elsewhere.

Populus canadensis Desf. Cottonwood. Not rare. May be found in occasional clumps in all low, moist situations. Is occasionally planted in groves or hedges.

Celtis occidentalis L. Hackberry. Not rare. Found only in timber along the larger streams—always on low land. Is occasionally transplanted and makes a very handsome lawn tree.

Aesculus flava Ait. Buckeye. A tolerably common species along Middle river and the Nodaway, but never found on Grand river.

Gleditschia tracanthus L. Honey locust. Not common. Is found in scattered groups along both the Nodaway and Middle river.

Prunus serotina Ehr. Wild cherry. Tolerably common along the roads and on all waste land.

Prunus americana L. American plum. Wild plum. Very common on all low lands. About equally abundant in the larger timber and along the small prairie streams where it and the wild crab are often the only species of trees. Occurs occasionally on the uplands in company with hazel, bur oak and sumac.

Ostrya virginica Willd. Ironwood. Not uncommon along the Nodaway, and may be found on Middle river, but not abundantly.

Cratægus coccinea L. Hawthorn. White thorn. Red haw. Common on low land, usually in larger timber.

C. tomentosa L. Black haw. Not very common. Found in greater abundance on the west than on the east side of the county.

Pyrus coronaria L. Crab apple. Very common on all low land, whether open or covered by larger timber.

Cornus paniculata L'Her. Dogwood. Common in thickets, both in valleys and on the higher land.

Rhus glabra L. Sumac. Common in thickets along the side and crest of river bluffs and on the high prairie. Found usually with hazel and bur oak.

Sambucus canadensis L. Elderberry. Common in thickets on all waste, rich land. Prefers the bottoms.

Prunus virginiana L. Chokecherry. Fairly common on all low land. Usually found in hick ts of other timber.

Corylus americana Walt. Hazel. Very common on all rough, rolling land, especially near the larger streams. Very seldom found on low land. Originally a great part of the prairie was covered with hazel, but most of it has been removed. A good deal yet remains, however, and all along the larger streams it is very abundant.

Salix nigra Marshall. Willow. Tolerably common on all low, moist ground.

Vitis æstivalis L. Wild grape. Common in all timber.

Lonicera parviflora Lam. Not common. Found occasionally in heavy thickets.

EFFECTS OF A SLEET STORM ON TIMBER.

BY JAMES E. GOW.

On the nignt of the 9th and the morning of the 10th of February, 1898, a heavy sleet storm passed over Adair county, Iowa. The storm began not very long after midnight w th a brisk rain which froze as it fell and adhered tenaciously to trees and other objects with which it came in contact. The

wind at the time was slightly west of north and was not blowing at all briskly. The day preceding the storm had been unusually warm, for the time of year, with a cloudy sky, a slight breeze from the north and a very humid atmosphere. About 3 o'clock on the morning of the 10th the trees, which had become heavily laden with ice, began to break. Had there been a heavy wind at the time, the damage to the trees would have been immense; as it was, the damage was very great and in the town of Greenfield the people were very generally awakened by the crashing of the breaking trees, which lasted almost continuously from 3 o'clock until daylight. Morning revealed the immense damage which had been done to the shade trees of the town. Most of these are soft maples and had yielded readily to the weight of ice, so that a large proportion of them were damaged and some were quite ruined. Owing to the stillness of the air the ice adhered about equally to all sides of the trees and, on trees of straight growth, the breakage was equal on the different sides.

The damage wrought by the storm was most severe on the soft maple trees, owing to the softness of their wood. Next, after them, the willows probably suffered most. In many places in the county willow hedges by the roadside were bent over until the trees nearly touched the ground and numbers of the trees were either broken short off or lost many of their branches. Hedges running east and west were worse affected than those running north and south, owing to the general tendency of the trees to bend toward the north. Hence in the former case the trees, having no support, were broken down by the ice, while, in the latter, they rested upon each other to some extent, and were saved from breakage. Box elder trees were badly damaged and elms were damaged almost as badly. Some handsome box elder trees in the town of Greenfield were almost ruined. A handsome weeping willow tree in Greenfield was literally stripped of all its smaller branches, not one being left unbroken. The accompanying illustration was taken of it just after the removal of the broken branches and may give some idea of how thoroughly the storm did its work. Oak, walnut and hickory trees resisted the ice well and were largely uninjured by it. Cottonwood trees suffered severely.

The amount of damage done to trees was largely determined by their position and habit of growth. Trees which grew

Weeping Willow Tree at Greenfield Stripped by Sleet.

upright shed the water and sleet well and were not greatly injured, while those which grew in a slanting position or were gnarled and straggling in their growth, did not shed it so well and consequently received greater injury. Limbs growing in a horizontial position were soon weighted down and broken while those more nearly vertical were saved.

In the native timber much damage was done and many trees were ruined, but the damage was not nearly so great as in the artificial groves, owing, doubtless, to the fact that the native timber tends naturally to grow in the best sheltered places and in such a manner as to protect itself, while, of the artificial groves, many are planted in exposed positions and in such a manner as to offer little resistance to a storm of this kind. In many of these groves the trees have been planted so close as to mutually choke each other, and consequently show a tendency to grow very tall, with a thin, spindling trunk and no branches lower than twenty or thirty feet from the ground. Wherever this condition prevails the damage done by the storm was very great. Throughout these groves we may see any number of shattered and maimed trees—evidences of the fact that the stunted trunks were unable to support the heavy masses of sleet which hung to the limbs. Trees which had distanced their comrades in the struggle for light and air by pushing up some distance above them suffered most severely and were almost invariably either broken off short or lost many limbs The fact that most of the artificial groves are of soft maple trees also goes far to explain the great damage which they sustained.

Trees growing in the open, as a rule, showed a better and stronger development than those in groves, and, hence, better ability to resist the storm.

In the case of most groves there is a very evident tendency on the part of the trees to lean toward the northeast—a tendency which has never been very satisfactorily accounted for, but is usually credited to the prevailing southwest wind of summer. This fact was emphasized by the results of the storm. An examination of almost any grove which suffered from the storm would reveal the fact that the greatest damage was done on the north and east sides and that, as a rule, the broken trunks and branches fell outward, while on the south and west they fell inward, or toward the center of the grove.

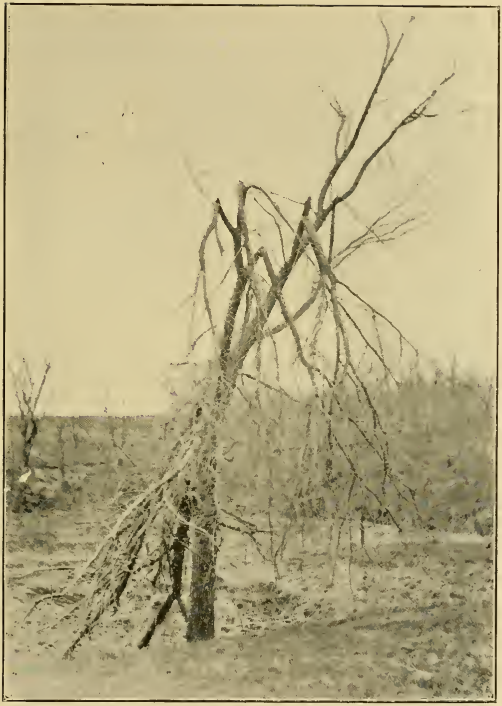
Naturally, the trees on the south and west were, to some measure, supported by those within, while those on the north and east, having no such support, succumbed to the sleet. A like effect may be noted in the case of trees in isolated localities, and in hedges. In hedges running east and west the greatest breakage was observable on the northern side—especially in the case of willow trees—whose leaning habit of growth made them particularly susceptible. In hedges running north and south the damage was not so great nor the effect so well marked, but here, as a rule, the greatest breakage was on the east. However, although these conditions were so general as to be readily observable, there were many apparently inexplicable exceptions, but in the main the effects of the storm were as here given.

THE AUGUST CLOUD-BURST IN DES MOINES COUNTY.

BY MAURICE RICKER.

It is my purpose to give merely a statement of facts concerning the storm which deluged Des Moines county the morning of August 16, 1898. I believe it was the heaviest rainfall ever noted in the United States for the period of its duration, and while the area covered was not large, it proved to be very destructive. No doubt there have been storms in which the precipitation was as heavy, where no one saw fit to chronicle the event. Many great disasters, as the Johnstown flood, with a greater area and less precipitation, have become historic because of loss of life.

My attention was called to the excessive rainfall that morning at daylight by the little swollen creek which divides South from West Hills in the city of Burlington. Yet this was in the very edge of the storm. The newspapers contained many sensational stories of narrow escape from loss of life, damage to county, city, railroad and farming interests. I read these with no special interest and dismissed their estimates of sixteen to twenty inches of rain in Flint valley as exaggerations so commonly found in popular accounts of natural phenomena. As soon as the tracks were repaired I had occasion to make



Soft Maple near Greenfield Broken by Sleet.

many trips by rail through the flooded district. The terrible strength of the water flow then became apparent and, noting the limited drainage area of Dry Branch in particular, I began to take more interest in the event, believing at this time that the real precipitation must be about five or six inches. I have since made a thorough canvass of the county and record for those interested in these phenomena only those things which are beyond dispute.

At 10 o'clock on Monday night, August 15th, it began to rain. The precipitation was not extraordinarily heavy, and while it rained steadily no one noticed that there was anything unusual about it. According to good authority, the so-called cloud-burst began about 2 o'clock A. M. and ceased shortly after 4. It rained more or less for an hour later, however. A liberal estimate of time for the heavy rain is three hours. The precipitation outside of these three hours, from all accounts, could hardly have been more than two inches.

The area of heavy rainfall can be approximately bounded on the south by the divide between Spring creek and Flint river. The former stream was not out of its banks. Keokuk reports a trace only. The county line forms a close boundary on the west, Yarmouth being in the edge of the heavy rain, but suffered only from lightning. Washington reports 1.72; Iowa City, .40. The north boundary of very heavy rain is not far above the county line, Wapello reporting 5.16. On the east, the river was the boundary for excessive rain, although the precipitation was heavy as far east as Biggsville, Ill. This maps out two-thirds of Des Moines county, or approximately 250 square miles. The Flint river and its tributaries drain one-half of this area. Dry Branch, Yellow Springs, Dolbee and Swank creeks drain the remainder, save a strip of three miles in width, which drains north into Louisa county. Dry Branch drains only about eleven square miles, yet its waters caused much damage. Yellow Springs creek drains a much larger area and carried, perhaps, more water, proportionately to its bed, than Dry Branch.

It is not easy to estimate the rainfall accurately. There were no rain gauges in the county at this time. I shall give some of the reports as I obtained them. Great care has been taken to get accurate and truthful accounts in this phase of the investigation.

Mr. J. W. Merrill, editor of the Mediapolis *New Era*, vouches for this story: A large circular windmill tank, with nearly straight sides, stood removed from bui dings upon level ground. It had never been used as a tank and was dry Monday night. It had a semi-circular cover, which was open, exposing one-half the tank to the rain. The water in the tank measured twelve inches in depth on Tuesday morning. We will grant that some of the water in the tank ran in from the half which was covered. Yet, had it all run in—and it could not—there would have been a rainfall of twelve inches. If the tank had been perfectly level, would more than one-half the water which fell on the cover have entered the tank?

In Dry Branch valley, below Latty, six miles south, lives a member of the county drainage board, a man whose judgment can be relied upon. He states that on Monday night an empty, straight-sided tin can which was used for mixing spray fluids for fruit trees, was left in open ground. The can was about fifteen inches in diameter and sixteen inches high. At 5 o'clock the can was full and running over. North of West Burlington lives a truck gardener, who left standing in the garden several sprinkling pots, whose open tops are half covered with tin in the usual manner. These ought to have shed one-half the water, yet daylight found them all with eight or nine inches of rainwater in them.

Other less reliable cases have come to my notice, where the hole of a barrel becomes the outlet for overflow, etc. The instances given suffice to show the character of the information which leads me to firmly believe that over an area of fifty square miles at least sixteen inches of water fell in three hours.

The instances of incredibly rapid rise in streams, even when already in the flood plains, seem to corroborate the estimates given above, while the records at the Mississippi bridge at 6 P. M., August 16th, show a stage of four feet five inches, a rise of three feet two inches. When we remember that local rain seldom affects the stage of water noticeably, and take into account the limited area of the storm, we must readily see that something extraordinary must have happened. The rain extended some distance up the river, it is true, Clinton reporting 3.01, Davenport 2.20.

The erosion was well in keeping with the figures given for rainfall. Little idea can be conveyed of the force of the water,

which tore up trees twelve inches in diameter and floated rocks weighing hundreds of pounds many feet from their former location. Hay stacks were floated bodily against steel bridges, carrying them many hundred yards down stream. In the city of Burlington whole timber piles floated from the yards and blocked the entrance to the great sewer Wagons and farm machinery of all kinds went down the Mississippi river, together with many dead animals. The oldest settler had never seen the water so high in these valleys. Many houses, barns, sheds, etc., were flooded, and this in spite of the rapid fall of these streams, which here break through the escarpment to the Mississippi.

The upper valleys broaden out with many fertile flats, often planted in truck and garden produce. The lower stream has low banks through the flood plain of the Mississippi. The rush of water necessarily did very great damage to both crops and soil. In many cases acres of ground which had been fall plowed were denuded of soil and left covered with sand and pebbles.

Flint river, which formerly entered into O'Connell slough after paralleling its course for half a mile, cut a new channel directly through cornfields to the slough, tearing out acres of soil with crops and timber. A raft of logs belonging to the J. D. Harmer Manufacturing company went down before it like straws. O'Connell slough, which had been the storage place for logs in summer and steamboats in winter, was piled with the debris, which will cost $15,000 to remove unless the ice and high water next spring can scour it out. Manufacturing establishments situated upon the slough will otherwise be cut off from navigation.

Hawkeye creek, a covered sewer through Burlington, became clogged with floating lumber and caused much damage to lumber yards, a foundry, the pickling works and the Murray Iron works. The stone apron at its mouth went out. The clearing of the sewer and the rebuilding of the apron will cause the city's heaviest bill for damage. The county lost twenty-three bridges, some of which have been replaced at an immediate outlay of $16,000. The Burlington, Cedar Rapids & Northern railway lost nearly two miles of track and five bridges. The bridges which replaced the lost ones are fine steel spans, much better than the old ones, costing $30.000. The loss to land owners is hard to estimate, but must have

been very heavy in crops and damage to soil. The loss of live stock drowned would probably have been almost as heavy had it occurred in daylight, owing to the very rapid rise of the streams. The estimate of $100,000 total loss is not far from correct.

There are many other interesting features which should be written up. The weather conditions can be obtained from the weather bureau. The map for the date shows a low reaching into Iowa, but would not warrant a forecast of general rain The energy liberated by so heavy a fall of rain would form an interesting study. I have collected some data concerning similar storms in previous years. The heaviest fall that has come to my notice was fifteen inches, at Wilmington, Del., on the 29th of July, 1839.

THE BURLINGTON ARTESIAN WELL.

BY FRANCIS M. FULTZ.

Work was commenced on the Burlington artesian well about midsummer of 1896; but, owing to cessation of operations for somewhat more than a year, it was not finished until midsummer of 1898. The well is located in Crapo park, and the expense of putting it down was borne out of the park funds.

It was expected that a flow would be reached in the St. Peter sandstone at a depth of about 900 feet. This belief was based on the flow obtained at the Ft. Madison and Keokuk wells, south of Burlington about twenty and forty miles respectively. As will be seen from the subjoined section the St. Peter was reached at a depth of 950 feet. No flow was obtained, but the water rose to within thirty-eight feet of the surface, and indicated a strong supply. There was no further change of the head of more than a foot or two, although the drilling was carried down to 2,430 feet and passed through at least two other water-bearing strata.

The diameter of the well is six inches for 1,700 feet and five inches for the balance. No casing is used excepting through the loess and drift. At 1,700 feet a test was made of the capacity. Over 100,000 gallons were pumped out daily for one

week, with no appreciable lowering of the head. At 2,430 feet, where the work was stopped, the pump was again put in and over 100,000 gallons were thrown out daily, for ten days, without lowering the head.

No analyses of the waters have yet been made. The water pumped out after the drilling was stopped, and which was probably composed of a mixture from the different levels, was clear and sparkling and remarkably free from objectionable mineral tastes. It was slightly diuretic and laxative. No extended experiments have as yet been made in using the water for park irrigation, which was one of the main purposes in putting down the well. It is hoped that the supply will be great enough to feed an artificial lake and a fountain or two. The pumping will probably be done by electrical power.

Through the kindness of the Tweedy Brothers, who carried the drilling down to 1,700 feet, and the Wilson Brothers, who finished the work, a very complete series of samples of the drillings came into my possession. From these, glass tubes have been filled, one being placed in the public library and another in the high school at Burlington, each showing, approximately, a complete section of the well. At four different levels the drillings were washed away by the pressure of the water from below, the material doubtless finding its way into crevices through which the well passes at higher levels. There were four of these intervals when no samples were obtained, the first at 1,475 feet, and continuing for forty-four feet; the second at 1,630 feet, and continuing for forty feet; the third from 1,725 feet to 2,000 feet, making a long interval of 275 feet; and the fourth from 2,360 feet to 2,400 feet, equal ing forty feet, making 400 feet in all from which no drillings were obtained.

The surface at the well is 685 feet above tide.

Number.	SECTION.	Thickness in feet.	Depth in feet.
66	Loess and drift	18	18
65	Limestone and chert, drillings coarse	23	41
64	Limestone, much less chert, drillings finer	37	78
63	Limestone, light buff, fine grained	19	97
62	Limestone, yellowish, sandy, cherty	13	110
61	Shale, sandy, with some lime	39	149

Number.	STATION.	Thickness in feet.	Depth in feet
60	Shale, light blue	126	275
59	Shale, dark blue	165	440
58	Limestone, compact, gray	140	580
57	Shale, gray	38	618
56	Shale, light blue	20	638
55	Shale, brown	50	688
54	Dolomite, brownish gray	49	737
53	Dolomite, dark gray, coarse grained	78	815
52	Dolomite, gray	10	825
51	Dolomite, pinkish gray, coarse grained	20	845
50	Dolomite, light brown, coarse grained	23	868
49	Shale, dark, slightly petroliferous	27	895
48	Shale, dark, dolomitic	15	910
47	Dolomite, with some little chert	16	926
46	Dolomite gray	19	945
45	Dolomite, white	10	955
44	Sand, pinkish	45	1000
43	Sand, mixed with black shale	40	1040
42	Sand, clean, white, fine grained	10	1050
41	Sand, clean, white, coarse grained	15	1065
40	Sand, darker, coarse grained	35	1100
39	Dolomite, white, compact	180	1280
38	Dolomite, pink, compact	15	1295
37	Dolomite, pinkish gray, compact	40	1335
36	Dolomite, pinkish, compact	15	1350
35	Sand, rusty, with some lime and chert	10	1360
34	Sand, rusty	20	1380
33	Sand, very sharp grained	20	1400
32	Sand, fine grained	10	1410
31	Dolomite, white, compact	9	1419
30	Dolomite, with brownish shale	13	1432
29	Sand, mixed with limestone and chert	13	1445
28	Chert, white	15	1460
27	Sand, fine grained, with some shale and limestone	15	1475
	Drillings washed away	44	1519
26	Sand, brown, rusty	6	1525
25	Limestone and chert, whitish	20	1545
24	Sand, limestone and chert	25	1570
23	Dolomite, grayish-brown	15	1585

Number.	SECTION.	Thickness in feet.	Depth in feet
22	Dolomite, light gray	15	1600
21	Limestone, light gray, with some chert and sand	30	1630
	Drillings washed away	40	1670
20	Sand, clean, white	20	1690
19	Dolomite, yellowish, sandy	35	1725
	Drillings washed away	275	2000
18	Limestone, dark gray, dolomitic	5	2005
17	Limestone, dark gray, nearly pure	5	2010
16	Limestone, dark gray, arenaceous	20	2030
15	Dolomite, dark gray, arenaceous	20	2050
14	Dolomite, rusty gray, with sand and shale	45	2095
13	Dolomite, rusty gray, mixed with pure limestone	20	2115
12	Dolomite, rusty gray, with much pure limestone	15	2130
11	Limestone, dark gray, with some little sand	15	2145
10	Limestone, mixed with sand and shale	80	2225
9	Limestone, brownish gray, with much sand	10	2235
8	Sand, light gray, with some lime	15	2250
7	Sand, light gray, dolomitic	20	2270
6	Sand, white, fine grained	5	2275
5	Sand, rusty, coarser grained	85	2360
	Drillings washed away	40	2400
4	Sandstone, very hard (12 hours in drilling 5 feet), many pinkish grains resembling quartzite; mixed with much shale and dolomite from above	5	2405
3	Same as No. 4, but with some little slate	5	2410
2	Slate, very dark, compact	10	2420
1	Slate, same as No. 2, but harder	10	2430
	Drill stopped in pure slate, at 2,430 feet.		

SUMMARY.

Number.	FORMATION.	Thickness.	Depth.
66	Pleistocene	18	18
64 65	Augusta—Upper Burlington	60	78
62-63	Augusta—Lower Burlington	32	110
59-61	Kinderhook	330	440
55-58	Devonian	248	688
50-54	Silurian	180	868
48-49	Maquoketa	42	910
45-47	Trenton	45	955

Number.	FORMATION.	Thickness.	Depth.
40-44	St. Peter	145	1100
36-39	Upper Oneota	250	1350
32-35	New Richmond	60	1410
30-31	Lower Oneota	22	1432
5-29	St. Croix	968	2400
3-4	Sioux Quartzite (?)	10	2410
1-2	Primitive (?)	20	2430

In the discussion of this paper Mr. Leverett called attention to the need of careful examination of the suposed Sioux quartzite drillings, especially since a well at the neighboring town of Aledo, Ill , reached a depth of 3,100 feet without touching the quartzite.

THE LOWER RAPIDS OF THE MISSISSIPPI RIVER.*

BY FRANK LEVERETT.

INTRODUCTORY.

In the early days of navigation on the Mississippi, two important rapids were found to interrupt the passage of vessels at low water stages; one, about fifteen miles in length, being above the city of Rock Island, Ill., and the other, about eleven miles in length, above the city of Keokuk, Iowa. These became known, respectively, as the upper and lower rapids. The latter are also called the Des Moines rapids because of the situation above the mouth of the Des Moines river.

In both rapids the obstructions consist of rock ledges, yet the form of arrangement of the ledges is not the same. The upper rapids consist of a succession of rock barriers called "chains," each usually but a fraction of a mile in breadth, which pass across the river channel and are separated by pools or stretches of slack water. The lower rapids are more uniform, there being a nearly continuous descent across them. The rate of descent, however, varies, as shown below. In open-

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ing the upper rapids to navigation it was necessary only to cut channels across the barriers, while in the lower rapids a canal has been constructed.*

The precise length of the lower rapids is 11.1 miles, the head being at Montrose island and the foot a short distance above the river bridge at Keokuk. The total descent is 22.17 feet, or very nearly two feet per mile. The rate of descent is greatest in the lower part, there being a fall of about four and one-half feet in the lower mile and nearly eight feet in the lower two miles.† Above this part the fall, though not uniform, is less definitely broken into rapids and pools than in the upper rapids. Indeed, there appears to be a rock floor forming the river bed throughout the entire length of the lower rapids.

Immediately above the head of the lower rapids a deep, preglacial channel appears, whose floor, as shown by several borings, is 125 to 135 feet below the low water level of the river. This is filled mainly with blue bowlder clay up to about the level of the river bed. Sand, however, in places, extends to a depth of nearly sixty feet below the surface of the river at low water, as shown by the bridge soundings at Ft. Madison and Burlington. A pool extends from the head of the rapids up to the vicinity of Ft. Madison—nine miles. The depth of the pool in places exceeds twenty feet at low water stage, thus extending to about that distance below the level of the rock surface in the river bed at the head of the rapids.

Below the rapids the river for four miles is in a narrow valley in which the depth of the drift filling is not known. It there enters a broad, preglacial valley, which has been found to constitute the continuation of that occupied by the river above the rapids, and which no doubt was excavated to a corresponding depth, though as yet no borings have been made

*This consists of a channel blasted out of the rock for a distance of three and one-quarter miles from the head of the rapids, below which a retaining embankment is built on the river bed along the Iowa side to the foot of the rapids at Keokuk.

†From Greenleaf's report on "Water Power of the Mississippi and Tributaries," tenth census of United States, 1880, Vol. XVII, p. 60, the following data are obtained. "In the first 4,800 feet from the lower lock there is a rise of 4.21 feet, then 2.22 feet in the next 3,600 feet, and 1.67 feet in the succeeding 3,600 feet to the middle lock, making the fall in ordinary low water, from a point opposite the middle lock to the foot of the rapids, 8.1 feet."

which reach its rock floor. The comparative size of the valley of the Mississippi, in its new channel across the lower rapids, and the partially abandoned preglacial valley, is shown in cross section in figure 6, of Vol. III of the Iowa Geological Survey. The depth of the new channel is but little more than half, and the width scarcely one-fifth, that of the preglacial channel. In size it is, therefore, scarcely one-tenth as large as the preglacial valley.

The small size of the Mississippi valley at the lower rapids, compared with its size above and below, was noted by Worthen more than forty years ago, and interpreted to be an evidence that the greater valley is preglacial, while the portion of the valley across the rapids is postglacial.*

Again, in his first volume of the Geology of Illinois, published in 1866, Worthen remarks (page 9) that the present river has shown, by the work done in the upper and lower rapids, how inadequate its erosive power would be to excavate in postglacial time the entire valley which it now but partially occupies.

A few years later Gen. G. K Warren discovered the abandoned section of the preglacial valley which crosses Lee county, Iowa, a few miles west of the lower rapids, and connects the portion occupied by the stream above the rapids with that below. In his report in 1878 he presented a discussion illustrated by a map setting forth the position of the old channel.†

General Warren based his interpretations upon the absence of rock outcrops in the valleys which traverse the old course

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*In his report to Hall, made in 1856, the following statement is found in the discussion of Lee county. (Geol. of Iowa, Vol. 1, 1858, p. 188):

"The valley thus scooped out of the solid rocks extends from Montrose to the mouth of Skunk river, and is from six to eight miles in width. The eastern portion of this ancient basin, except the bluffs on the river above Ft. Madison, is now covered by the alluvial deposits before mentioned, while the western part is occupied by deposits of drift material from 100 to 185 feet in thickness That this valley was formed by ancient currents, previous to the drift period, is proved by the fact that a considerable portion of it is now occupied by deposits of that age, and which must have been formed after those currents ceased to act."

†Report of the U. S. Army Engineers for 1878-9, Vol IV, part 2, pp. 916-917, Diagram E, also Diagram 1, sheet 4.

of the river, there being no borings that extended to the rock bottom. A few years later a boring at Mont Clare, Iowa, was sunk in the old valley and brought confirmation to General Warren's interpretation.* The accompanying sketch map, figure 2, sets forth the position of the old valley and its relation to the one across the rapids.

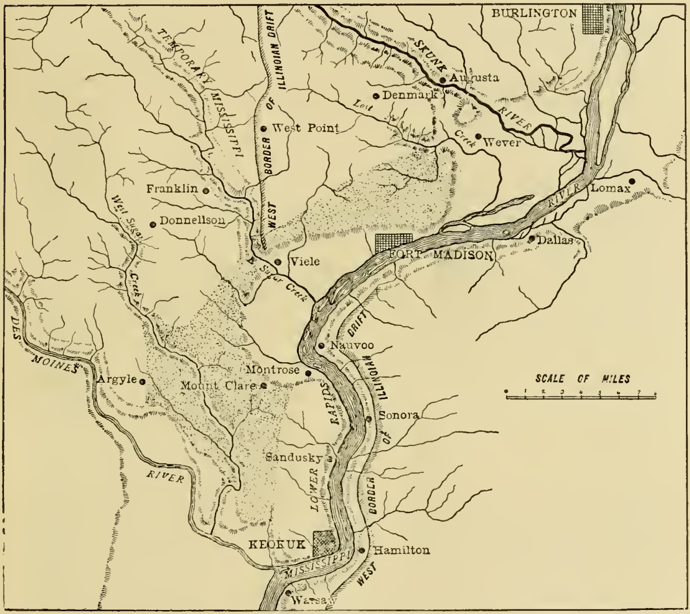

Figure 1. Sketch map of region discussed, showing course of old channels.

NOTE OF EXPLANATION.—The abandoned portion of the pre-glacial channel of the Mississippi is shaded. Hachures are used to indicate valley borders both below and above high terraces and along the temporary Mississippi channel, opened at the Illinoian stage of glaciation. The extent of the high terrace in Missouri has not been determined.

It should not be inferred that this broad, preglacial valley was necessarily a line of discharge for the whole of the present drainage basin of the upper Mississippi. The available evidence concerning the preglacial drainage, though imperfect, is thought to indicate that a large part of the region

* Buried River Channels in Southwestern Iowa, by C. H. Gordon, Iowa Geol. Surv. Report for 1893, pp. 236-255. Figs. 5, 6 and 7. Published in 1895 as Vol. III of the present survey

above the upper rapids may have trained southeastward through the Green river basin to the Illinois. Hirshey has suggested a northward discharge for the headwater portion of the basin,* a suggestion that awaits adequate investigation. The preglacial valley, which passes the lower rapids on the west, is nearly coincident with the present Mississippi, from the head of these rapids up to Muscatine, but its position farther north has not been ascertained, nor has the size of its drainage basin been even approximately determined. It is probable, however, that much of eastern Iowa was tributary to this preglacial line.

DATE OF THE DEFLECTION ACROSS THE LOWER RAPIDS.

In previous years attention has been called, both by Mr. Fultz and myself, to evidence that the region around the lower rapids presents a complicated glacial history.† It has been shown that one ice field extended southward from Kewatin, in the Dominion of Canada, across Manitoba, Minnesota and Iowa into Missouri and that it spread eastward beyond the valley of the Mississippi, from near the southern end of the driftless area of the upper Mississippi, to the vicinity of Hannibal, Mo. Two invasions may have been made by that ice field with an intervening deglaciation interval of some length, as indicated by Bain‡. The later, and probably the more extensive, advance is referred to the Kansan stage of glaciation.

It has also been shown that subsequent to the Kansan stage of glaciation an ice field extended from Labrador and the heights south of Hudson bay southwestward across Michigan, the Lake Michigan basin and Illinois into southeastern Iowa.

The Kewatin ice field not only covered the preglacial valley near the lower rapids, but also the district which the stream traverses in passing the rapids. It was thus liable to have displaced the stream to a much greater extent than the deflection past the rapids, as indicated below. The invasion from Labrador, on the other hand, appears to have barely reached to the rapids, and may not have interfered seriously with drainage across them, though it greatly disturbed the course

* American Geologist, Vol. XX, 1897, pp. 246-263.

† F. M. Fultz, Proc. Iowa Acad. of Sciences for 1895, Vol. II, pp. 209-212.
Ibid. 1896, Vol. III, pp. 60-62.
Frank Leverett, Science, Jan. 10, 1896.
American Geologist, Feb., 1896.
Bull., No. 2, Chi. Acad. Sci., May, 1897.
Proc. Iowa Acad. Sci., 1897, Vol. V, pp. 71-74.

‡ Proc. Iowa Acad. Sci. for 1897, Vol. V, pp. 86-101.

of the Mississippi above the rapids. It did not reach the section of the preglacial valley west of the rapids. The inflection from the preglacial channel must, therefore, be due to the Kewatin ice field.

But, since the Kewatin ice field may have twice invaded this region, it is necessary to inquire into the probable effect of each of its two invasions. If it be found that the earlier invasion extended beyond the line of the preglacial valley, and deposited sufficient material to prevent the re-establishment of the river along the preglacial line, a deflection at this early date must have occurred. The deflection, however, need not necessarily have thrown the stream into its present course across the rapids. That course may have been taken as a result of the later invasion of the Kewatin ice field, if not as a result of the still later encroachment of the Labrador ice field. It is reasonable to suppose that the deflection caused by the Kewatin ice field might give the stream a course farther to the east than the lower rapids, since the region across which the rapids have been opened appears to have been entirely covered by the Kewatin ice field at each of its invasions. It will be necessary, therefore, to determine whether the Kewatin field did not establish the Mississippi in a course east of the rapids, and whether that course was not held by the Mississippi until the Labrador ice field forced it westward into its present course across the lower rapids.

Turning now to the question of the influence of the supposed earlier invasion of the Kewatin ice field, a few remarks seem necessary concerning the deposits made by that ice field. The lowest conspicuous member of the drift series in eastern Iowa is a sheet of dark blue till, often nearly black, which is thickly set with fragments of wood and coal. This is overlain by a sheet of blue-gray till which differs from the blue black till in texture and rock constituents as well as in color. It shows a decided tendency to break into rectangular blocks, and often presents vertical fissures extending to a depth of many feet, which are filled with sand or deeply oxidized clay. The blue-black till is very friable, and seldom shows a tendency to break into rectangular blocks, while the few fissures which it contains traverse it in oblique, rather than vertical, lines. The blue-gray till carries much less vegetal material and coal fragments than the blue black till. It differs also from the blue-black till in containing a larger percentage

of greenstone rocks. These differences have naturally led to the suspicion that two quite distinct sheets of till are present and this suspicion is confirmed by the occasional occurrence of a black soil at the surface of the blue-black till. Such exposures are rare compared with those of the Yarmouth soil found between the Kansan and Illinoian till sheets,* but their rare occurrence may not demonstrate that the interval of deglaciation is of minor importance. From conversations with Calvin, Norton and Bain, I am led to think that a large part of the buried soils reported by McGee, from eastern Iowa,† occupy a horizon corresponding to the junction of the blue-gray and blue-black tills of southeastern Iowa. This being true, the interval of deglaciation between the blue-gray and blue-black tills becomes of much importance.

The sheet of blue-black till has been found to occur at points farther east than the lower rapids. It occurs in the Mississippi valley in the vicinity of Ft. Madison, Iowa, and in Hancock and Adams counties, Illinois, east and southeast of the rapids. There is little doubt, therefore, that during the deposition of this till the Kewatin ice field was *sufficiently extensive* to force the Mississippi out of the preglacial channel which passes west of the lower rapids.

It is not certain, however, that the *amount of filling* in that valley was sufficient to prevent the return of the stream to its preglacial course in the interval between the deposition of the blue-black till and the blue-gray till. The blue-black till in the vicinity of Ft. Madison is found to rise to a height of only sixty to seventy-five feet above the present stream, or nearly seventy-five feet less than would probably have been necessary to throw the stream from the preglacial channel into its present course across the rapids. This may possibly have been sufficient to throw the drainage of the portion above the lower rapids eastward into the Illinois, either by way of the Green river basin or by some line farther south that is now completely concealed by the later sheets of drift. But it seems quite as probable that the stream returned to its preglacial course,

The blue-gray till seems to be fully as extensive a sheet as the underlying blue-black till. It extends eastward into

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* See Proc. Iowa Acad. Sci., Vol. V, 1897, pp. 81-86.

† Eleventh Annual Report U. S. Geol. Surv., 1889-90, pp. 232, 233, 485, 496, 541, 569.

Illinois beneath the Illinoian till sheet an undetermined distance. The tendency to break into rectangular blocks often serves to distinguish it from the overlying Illinoian till, as well as from the underlying blue-black till, though the Illinoian, in places, takes on this phase of fracture. Probably the most extensive of the exposures of the blue-gray Kansan till are found in the vicinity of Ft. Madison. It there constitutes, for several miles, the upper 100 feet of the Mississippi bluff, except a thin coating of loess.

The filling produced by the blue-gray till was sufficient to prevent the return of the stream to its preglacial course, for the altitude of the surface, along the part of the preglacial channel west of the lower rapids, is as great as in border districts. In this case, therefore, it is only necessary to decide whether the stream assumed its present course across the lower rapids at the time the Kewatin ice field made its final withdrawal from that region, or whether it drained eastward to the Illinois until it was forced from that course by the advance of the Labrador ice field at the Illinoian stage of glaciation. Concerning this question it is thought that evidence of some value has been collected, as appears below:

EROSION PRECEDING THE ILLINOIAN STAGE OF GLACIATION.

The Mississippi valley, for about fifty miles below the lower rapids, was greatly filled by the drift from the Kewatin ice field. Immediately below the rapids the filling on the borders of the valley reached a level about 150 feet above the present stream. It seems not improbable that there was a filling to nearly this height in the middle of the valley, for the abandoned section just above was filled in its middle part to as great height as on its borders. Upon passing down the valley the height of filling gradually decreases to the limits of the Kewatin drift near Hannibal. From the filling of tributaries near Hannibal, it is estimated that the Mississippi valley could not have been filled to a height greater than seventy-five feet above the present stream. Below Hannibal the filling was produced by stream action, rather than by glacial deposition, and appears to have reached but little, if any, above the sand terraces of the valley—say fifty feet above the river. Now, if this filling suffered but little erosion before the Illinoian stage of glaciation, it can reasonably be inferred that the drainage of the upper Mississippi did not pass across the lower rapids

and through this part of the valley until forced westward by the advance of the Labrador ice field. But if a great erosion took place in this part of the valley prior to the Illinoian stage of glaciation, there would seem good grounds for supposing that the stream assumed its present course soon after the Kewatin ice field made its final withdrawal.

Examining into this question, it is found that after this drift was deposited by the Kewatin ice field an erosion so great took place that it was removed, throughout the greater part of the width of the valley, down to a level scarcely fifty feet above the present stream at the mouth of the Des Moines, and to an equally low level at Hannibal. The depth of cutting appears, therefore, to have been about 100 feet at the mouth of the Des Moines and perhaps twenty-five feet at Hannibal. It seems safe to assume an average depth of fifty feet for the entire section and a width of five or six miles, making an erosion of nearly three cubic miles of drift in the fifty miles below the mouth of the Des Moines river. It is scarcely necessary to raise the question whether this erosion could have been accomplished by the Des Moines and other tributaries of the Mississippi below the rapids, for it is evidently out of proportion to the work which these small streams would be able to accomplish since the Kansan stage of glaciation. It seems certain that the Mississippi river is responsible for the principal part of the erosion. This makes necessary the opening of the new channel across the rapids, since the old channel west of the rapids was not utilized by the river after the Kansan stage of glaciation, and no other line of drainage could have been adopted by the river that would pass through the portion of the valley below the rapids.

Evidence is found within the new channel, of an erosion such as the interpretation just given demands. In the south part of Keokuk, between the foot of Main street and the mouth of Soap creek, the rock bluff rises but fifty to sixty feet above low water and is capped by a bed of bowlders about twenty feet in depth. Attention was called to this bed some thirty years ago by Mr. S. J. Wallace of Keokuk,* and the view expressed that it is "old river shingle." Mr. Wallace stated that Dr. George Kellogg, of Keokuk, regarded it as an indication of an ancient fall at this place, but that he did not so regard it.

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* Proc. A. A. A. S., Vol. XVII, 1869, p. 344.

This bed has been discussed at some length by Mr. Gordon in the Geology of Iowa,* and three interpretations for its origin are presented.

First.—That it was formed by river action alone, *i. e.*, as an alluvial bar.

Second.—That it is due to the cutting down of a till sheet, the coarse material being left as a residue.

Third.—That it is a bowldery moraine dropped at the edge of the ice sheet at the Illinoian stage of glaciation.

Of the three interpretations the second seems to Mr. Gordon, as well as to the present writer, the most applicable. Dr. Kellogg's suggestion of a fall as the cause seems, at best, to be poorly sustained. A similar bowlder bed occurs near Warsaw, Ill. It there forms a capping for an eroded till surface and bears clear evidence of removal of the fine material by a stream, with the retention of the bowlders as a residue. A bowlder bed is also found along the face of the west bluff of the rapids near Sandusky, about six miles above Keokuk, at a level forty to sixty feet above the stream, that probably was derived from the erosion of a sheet of till, though the exposure is scarcely extensive enough to show clearly the relationship. It seems referable to the period of erosion that produced the beds at Keokuk and Warsaw.

The amount of erosion effected is so great that the beginning of this new channel seems to date from near the close of the Kansan stage of glaciation. This becomes more evident as we study into the later stages of the history of the river. Even if the river had been forced into a channel farther east than the lower rapids, it seems scarcely probable that it remained long in that course. It apparently began its work of opening the course across the rapids long before the Labrador ice field had reached the region.

FILLING AT THE ILLINOIAN STAGE OF GLACIATION.

Following this great erosion there came a partial filling of the part of the valley immediately outside the limits of the Illinoian drift sheet. It is well displayed below the rapids, and some remnants are to be seen along the borders of the rapids. This filling appears to have occurred at the Illinoian stage of glaciation: Evidence of this relationship is to be found in the connection, or close association, of this filling

*Geology of Iowa, Vol. III, 1893, pp. 252-255. See also Pl. XV.

with the opening of a temporary course for the Mississippi across southeastern Iowa, which occurred at the time the Mississippi valley above the rapids was covered by the Labrador ice field.

The drainage line referred to leaves the present Mississippi at the mouth of the Maquoketa, passes southward along that valley (reversed) to Goose Lake channel, and thence to the Wapsipinicon valley, coming to that valley a few miles above its present mouth. It follows up the Wapsipinicon a few miles to the mouth of Mud creek, a southern tributary, which, together with a small tributary of Cedar river also called Mud creek, furnishes the line of continuation for the old valley to the Cedar river near the great bend at Moscow. The valley continues southwest to the Iowa river along the course now followed by the Cedar river in its lower twenty-five miles. It then passes southward from Columbus Junction to Winfield and thence westward to Skunk river at Coppock, opening in its westward course two lines, one of which is now utilized by Crooked creek. From Coppock the old drainage line follows the course of Skunk river southward to Rome, and Cedar creek (reversed) to Salem. It there turns southeastward, being known as "Grand valley" in northern Lee county, and joins the Mississippi about six miles west of Ft. Madison, nearly opposite the head of the rapids. Its continuation was evidently across the rapids into the broad valley below Keokuk.

The altitude of the bottom of this old valley, near the head of the rapids, is fully 100 feet above the present stream, but connects well with the surface of the valley filling in and below the rapids. It is nearly 100 feet lower than at the point where it leaves the Iowa valley, seventy-five miles to the north. The portion above the point where the Iowa valley is crossed has been so modified since the Illinoian stage of glaciation that very little is known concerning its condition at the close of that glacial stage, but the portion south from the Iowa valley has been only slightly modified.

Very little material was deposited on the bed of the temporary channel of the Mississippi in the seventy-five miles from the Iowa valley to the head of the rapids, but a great filling occurred in the broad valley below the rapids, and some filling along the rapids, especially at their lower end. The valley, which, at the foot of the rapids, had been cut down

to a level scarcely fifty feet above the present stream, was built up to eighty or ninety feet above the river at that point. The depth of filling is found to increase upon passing down the valley, and becomes scarcely noticeable at Hannibal. It is, therefore, much like a delta, formed where a rapid stream emerges into a sluggish, lake-like body of water. It consists mainly of fine material, sand or silt, with few pebbles greater than one-fourth inch in diameter. A fine gravel, however, appears at an exposure called "Yellow Banks," near the mouth of the Des Moines river. The bowlder bed in Keokuk, described above, received at this time a capping of sand fifteen or twenty feet in depth. Sand deposits are also found at a corresponding level in Hamilton, Ill., near the foot of the rapids, capping a low part of the rock bluff. Another possible remnant of the sand filling is found at Sandusky, Iowa, six miles above Keokuk, immediately back of the bowlder-strewn slope, noted above. It there rises about eighty feet above the river, or to within twenty-five feet of the level of the bottom of the channel of the temporary Mississippi, ten miles to the north. No remnants of the filling have been noted in this interval of ten miles and it is thought probable that the rate of fall was so great above Sandusky that but little lodgment of material occurred.

In the portion of the Mississippi valley covered by the Labrador ice field at the Illinoian stage of glaciation, there appears to be no such sand filling as is found below the rapids, although it has nearly as low a gradient. This feature confirms the above interpretation, that the sand filling occurred during this stage of glaciation.

In explanation of the small amount of material deposited in the bed of the temporary Mississippi, Professor Chamberlin has suggested to me that the ground in which this channel was excavated may have been frozen at the time of excavation, its situation being on the immediate borders of the ice sheet, and that this frozen condition of the ground may have prevented the stream from eroding more material than it could readily transport

The time involved in the valley filling is a question of much interest, but one on which an estimate is very difficult to make. The filling of any given section is not a measure of the full work of the stream, but simply an index to the excess of material above the limits of transportation by the stream.

To properly estimate the work in a stage of filling it is necessary to compute the amount of material carried through the channel, as well as that deposited in it. It is doubtful if present methods of study are sufficiently refined to enable one to make even an approximate calculation of the time involved. It may safely be affirmed, however, that the filling under discussion progressed slowly, and that the time involved was sufficiently long to affect materially the chronology of the lower rapids.

EROSION CONDITIONS DURING THE SANGAMON INTERGLACIAL STAGE.

Between the Illinoian stage of glaciation and the deposition of loess, which accompanied the Iowan stage of glaciation, there was a long interval of time during which the surface of the Illinoian drift sheet was subjected to leaching, and weathering, and the formation of a soil. The name Sangamon has been applied by the present writer to the soil and weathered zone formed at this time, and may properly be made to denote the time interval.* Although the degree of weathering and leaching makes it evident that the interval was protracted, the valley excavation appears to have been comparatively slight, so far as depth is concerned. This is true not only in the region about the lower rapids, but throughout the entire exposed portion of the Illinoian drift sheet.

The erosion on the lower rapids appears to have been scarcely sufficient to remove the sand filling which occurred during the Illinoian stage of glaciation. It could have amounted to scarcely twenty feet in depth and was mainly in loose material. The limits of the erosion are determined by the level down to which the loess extends. That deposit appears nowhere *in situ* at a lower level than sixty-five to seventy-five feet above the head of the rapids. Its lower limits, in the portion of the valley above the rapids, are also as great as seventy feet above the present stream.

A study of tributary valleys in this region has shown that the streams meandered widely and performed a large amount of work, notwithstanding the shallow depth of erosion. For example, Skunk river, in southeastern Iowa, at that time meandered over a width of about two miles (see figure 2),

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*Proc. Iowa Acad. Sci., Vol. V, for 1897, pp. 70-80. Journal of Geology, Vol. VI, 1898, pp. 171-181

whereas it is now confined to an inner valley scarcely one-half mile in average width. It should be noted, however, that the erosion of fifteen or twenty feet over a width of two miles, by a stream with sluggish current, may involve more time than is required for the cutting of the inner valley, which has an average depth of nearly 100 feet and a width of about one-half mile.

In this interval, as in the interval of filling which preceded it, the rapids suffered but little modification, yet the time involved was sufficiently long to affect materially the estimates of the duration of the stream in its present course.

THE LOESS FILLING ACCOMPANYING THE IOWAN STAGE OF GLACIATION.

The period of low gradient and slack drainage, just discussed, was followed by even less favorable conditions for the opening of a channel During the Iowan stage of glaciation, as long since pointed out by McGee* and elaborated by Calvin and others,† the deposition of a sheet of silt occurred, not only along the main valleys, but over much of the low country in the interior of the Mississippi basin. This silt is the problematical loess. Its mode of deposition is still a matter of dispute, the deposit being thought by some glacialists to be largely aqueous, while by others it is thought to be chiefly æolian.

In the region under discussion the valleys, as previously indicated, were opened only to shallow depths hence but slight accumulation of the silt was necessary to fill them or to cause the streams to spread over the bordering plains. The depth of the silt in the vicinity of the lower rapids seldom reaches thirty feet and probably averages not more than fifteen feet. Its bulk, therefore, does not, so far as the valleys are concerned, greatly exceed that of the filling which occurred below the rapids during the Illinoian stage of glaciation. If, however, the deposits on the bordering plains are taken into consideration, the amount of material deposited is very much greater, for the plains were covered to a depth of six to ten feet by this silt.

*The Drainage System and Distribution of the Loess of Eastern Iowa, by W. J. McGee, Bull. Wash. Phil. Soc'y, Vol. VI, 1883, pp. 93-97. Also see discussion in Eleventh Ann. Rep't U. S. Geol. Survey, 1890, pp. 435-471.

†Geology of Jones County, by S. Calvin, Iowa Geol. Survey, Vol. V, 1895, pp. 63-69. Geology of Johnson County, by S. Calvin, Iowa Geol. Survey, Vol. VII, 1896, pp. 39-45, 86-89. Geology of Linn County, by W. H. Norton, Iowa Geol. Survey, Vol. IV, 1894. pp. 168-184. Geology of Marshall County, by S. W. Beyer, Iowa Geol. Survey Vol. VII, 1896, pp. 234-238. Geology of Plymouth County, by H. F. Bain, Iowa Geol. Survey, Vol. VIII, 1897. pp. 335-351.

Whether the deposition took place by water or by wind, there seems to have been a suspension of erosion on the lower rapids, and the length of this suspension must certainly be sufficient to affect materially their duration. An estimate of the time involved seems at present impossible, there being fewer data for an estimate than in the filling which occurred at the Illinoian stage.

EROSION FOLLOWING THE LOESS FILLING.

After the deposition of the loess, the valleys throughout much of the Mississippi basin experienced a marked deepening, which brought their bottoms to a lower level than before the loess filling. In the portion of the Mississippi valley which lies within and near the rapids the deepening seems to have proceeded continuously to a level nearly as low as the present stream, or fifty to seventy-five feet below the excavation which occurred in the interval following the Kansan glaciation. This excavation, in the section embraced within the rapids, was mainly rock, for the loess and alluvium had built up the channel scarcely thirty feet above the rock floor of the post-Kansan erosion. But for some distance, both above and below these rapids, the excavation was largely in till. The channel across the rapids was opened to a width but little greater than the stream, or about one mile. Elsewhere the channel is three to six times the width of the stream.

This erosion seems to have continued until the early part of the Wisconsin glacial stage, when, as indicated below, another filling occurred. The extent and depth of the erosion which took place prior to the Wisconsin filling, is well shown in the broad portion of the valley above the rapids. Numerous wells indicate that the till had been removed nearly to present river level, over the greater part of the width of the valley, before that filling set in.

The amount of erosion in the Mississippi valley seems to have been nearly as great in this interval as in the post-Kansan interval of erosion. It is doubtful, however, if the time involved was so great as in that interval, for the gradient appears to have been higher. To properly estimate the time involved, it is necessary also to know the volume of water discharged through the valley at each interval, a matter concerning which very little is yet known.

FILLING AT THE WISCONSIN STAGE OF GLACIATION.

At the Wisconsin stage of glaciation the Mississippi and several of its tributaries, which flowed away from the ice sheet, became so burdened by glacial detritus that they were unable to completely transport their load, much less to continue the erosion of their valleys. The Mississippi headed in the ice sheet near St. Paul, Minn., while the Chippewa and Wisconsin rivers brought material from the Chippewa and Green bay lobes of Wisconsin. Rock river, also, brought material from the Green bay lobe and through its tributaries, Kishwaukee and Green rivers, from the Lake Michigan lobe. Just above St. Louis the Illinois river contributed a large amount of material, derived from the Lake Michigan lobe. These streams discharged such large quantities of sand into the Mississippi that its valley was greatly filled as far down as the head of the broad valley of the lower Mississippi at Cairo. Throughout much of the interval between St. Paul and Cairo the valley was filled to a height of fifty to seventy-five feet above the present stream. In the vicinity of the rapids it reached nearly fifty feet above the level of erosion in the preceding stage of deglaciation.

The filling probably began during the early part of the Wisconsin stage of glaciation, but the great bulk of it appears to have been contributed during the part of the Wisconsin stage of glaciation represented by the Kettle-morainic system. The transportation of sand down the valley no doubt continued for a long time after the ice sheet had ceased to contribute material to the headwaters of the present Mississippi. The filling may, therefore, have occupied a longer time than that involved in the formation of all the moraines which cross the headwaters of the Mississippi.

The greater part of this filling consists of sand of medium coarseness. This, however, is interbedded with thin deposits of very fine gravel. and pebbles are also scattered through the sand. The pebbles seldom exceed one-half inch in diameter and are usually one-fourth inch or less. They have been noted by the writer as far down the valley as the vicinity of Quincy, Ill. They are a conspicuous feature above Rock Island, Ill. Upon following up the tributaries of the Mississippi toward the head of these valley trains, the material becomes markedly coarser, as is to be expected, on the theory of their derivation from the ice sheet.

It scarcely needs to be stated that so great a filling has greatly interrupted the removal of the rock barriers of the Mississippi at each of the rapids. A stream, with the present volume of the Mississippi, and its comparatively low gradient of about six inches per mile, can scarcely do more than remove the material brought in by its tributaries, to say nothing of removing the great amount of material deposited at the Wisconsin stage of glaciation. There appears, however, to have been a long period succeeding this sand deposition in which the volume of the Mississippi was much greater than at present, and this matter will next receive our attention.

EROSION ACCOMPLISHED BY THE LAKE AGASSIZ OUTLET.

Following this period of sand deposition the Mississippi valley afforded a line for the discharge of a large area now tributary to Hudson's bay, an area which was occupied by the glacial lake, Agassiz. The area of this glacial lake, and of the country tributary to it, is estimated by Upham to have been from 350,000 to 500,000 square miles.* This great drainage area has been reduced to about 12,000 square miles† now tributary to the Mississippi through the Minnesota river. The present drainage area of the Mississippi, above the lower rapids, does not exceed 125,000 square miles, or about one-third the minimum estimate of Upham for the area of Lake Agassiz and its tributaries. Although this great reduction has been in the arid portion of the old drainage basin, it must greatly affect the volume of the river. The present run-off of that region can scarcely furnish a full index, since the ice sheet was also a great contributor of water to the glacial lake.‡

It can scarcely be questioned that at the height of the discharge from Lake Agassiz the volume of water was fully four times that of the present Mississippi. This view is sustained, both by the amount of erosion which took place, and by the low gradient reached by the stream. The sand which was deposited as a glacial outwash, while the ice sheet occupied the headwaters of the present Mississippi, was largely

* "The Glacial Lake Agassiz," by Warren Upham, Monograph XXV, U. S. Geol. Survey, 1895, pp. 50-64.

† Warren's Report Bridging Mississippi River, Chief of Engineers U. S. Army, 1878-79, Vol. IV, p. 924.

‡ In addition to the change of drainage area involved in the Glacial Lake Agassiz, it is necessary to take into consideration the influx of water from the glacial lake which occupied the western end of the Lake Superior basin, and also a small glacial lake at the head of Green Bay in Wisconsin.

removed by the Lake Agassiz outlet throughout the entire distance from St. Paul to Cairo. It is estimated that the average width of the channel formed by this outlet is three miles, or about four times the breadth of the present steam.

The depth of erosion seems to have been such as to give portions of the stream a lower level and lower gradient than that of the present river. This is especially noticeable in the portion above the upper rapids, as indicated by General Warren.* Lake Pepin, an expansion of the Mississippi, situated just above the mouth of the Chippewa river, has a depth of about sixty feet. It was General Warren's opinion that when the flow of water from the great northern basin ceased there would no longer be the volume of water necessary to remove the deposits brought in by the Chippewa river. In consequence of this change the Mississippi has been lifted to a level about sixty feet above its former bed. Evidence of a similar filling, produced by the Mississippi at the mouth of the Minnesota, is cited by General Warren. He also noted evidence of the marked shoaling of the Mississippi at the mouth of the Wisconsin. He further expressed the opinion that the entire cutting now in progress on the Mississippi may be confined to short sections in the vicinity of the rapids.

It is of interest to note what a slight change is required to stop the cutting at these places. A filling of only twenty-five feet at the mouth of the Des Moines, or of Rock river, is necessary to cause the neighboring rapids to become protected from erosion. It is not probable, however, that either of these tributaries will, for some time, begin the filling of the valley at the foot of the rapids, for the fall of the Mississippi, in passing each of the rapids, is greater than that of the lower course of the Rock or the Des Moines. Furthermore, the main stream has the advantage of much greater volume than these tributaries, in consequence of which the fall across the rapids must be reduced below that of the tributaries before filling can begin at their mouths.

CONTOURS OF THE BLUFFS ALONG THE LOWER RAPIDS.

The great length of time involved in the development of a channel across the rapids is shown by the contours of the bluffs. Except at a few points, where the river in rounding a curve has recently encroached upon its bluff, there is not an

*Op. cit pp. 911-916.

abrupt face. A large part of the slope is so gradual that it has been brought under cultivation When it is considered that the bluff is composed mainly of a firm limestone, the height of the rock portion ranging from fifty up to 150 feet, with an average height of nearly 100 feet, the prevalence of a moderate slope must indicate a long period of excavation.

But little is yet known concerning the manner in which the rock barrier has been cut away, whether by the recession of a fall or by the present process of slow cutting across its whole breadth. The fact that the old valley below the rapids was filled with drift about to the height of the highest part of the rock barrier, lends support to the view that there has been a slow cutting down of the entire width of the barrier, rather than the recession of a fall. It seems scarcely probable that the till beneath the stream was scooped out to a much greater degree below the rock barrier, in the early stages of excavation, than at the present day.

COMPARISON WITH THE UPPER RAPIDS.

The work performed in cutting away the rock barrier, at the lower rapids, appears to be several times as great as at the upper rapids. In the latter the rock excavation has not been sufficient to remove the prominent parts of the barrier. It scarcely amounts to an average cutting ten feet in depth. In the rapids under discussion the barrier is estimated to have suffered a rock excavation to a depth of nearly 100 feet, or about one fourth of a cubic mile. This difference in amount of work accomplished is readily accounted for by the earlier date at which the lower rapids began excavation. The excavation, as shown above, appears to have begun soon after the Kansan stage of glaciation, while the excavation at the upper rapids appears to have set in after the Illinoian and to have been mainly accomplished since the Iowan stage of glaciation.

THE LOWER RAPIDS AS A CHRONOMETER.

When this investigation was entered upon by the writer, hopes were entertained that the channel across the lower rapids would furnish a valuable chronometer for determining the time since the Kansan stage of glaciation. But from what has been shown it is evident that the determination of the time is at present very difficult, if not impracticable. It may be thought that this channel will furnish a chronometer for

the relative dates of the Kansan, Illinoian, Iowan and Wisconsin glaciations. But on this question scarcely more than a very rude approximation is likely to be reached. As indicated above, the work involved in filling is especially difficult to determine. These difficulties, however, are no greater than those involved in the estimates of the changes of drainage area which the Mississippi has experienced. The object of the present paper is accomplished if the complexity of the history has been adequately presented. The chronological determinations must be deferred to a time when more refined methods of investigation are instituted than are now at command.

OBSERVATIONS ON THE GEOLOGY OF STEAMBOAT SPRINGS, COLORADO.

BY F. M. WITTER.

In the year 1873, a division of geologists under the management of Dr. F. V. Hayden, made a survey of the region from Willow Creek pass, between North and Middle Parks, across the park range down the Yuma or Bear river to the White river, around to Eagle river and up the Grand, of which Willow creek, in Middle Park, is a tributary. In this report, very brief mention is made of Steamboat Springs, although the trail on their map does not pass nearer than twenty-five or thirty miles to the Springs.

Steamboat Springs is now not far from 100 miles by wagon road from a railway. Rawlins, on the Union Pacific in Wyoming, is probably the nearest railroad point on the north, and Glenwood Springs, on the Denver & Rio Grande, is the nearest on the south. Last July our party left North Park in its extreme southwest corner at Rabbit Ear peak. This mountain is the most conspicuous in the park range, immediately west of North Park. From near Pinkhampton, in the northeast corner of North Park, Rabbit Ear is plainly visible, a distance of sixty miles or more. This peak is capped by two immense vertical rocks about 100 feet apart. These rocks have suggested the name for the peak. By means of a spruce-tree ladder we climbed to the top of one of these huge "ears." We

could then see the whole of North Park, and much country in every direction, probably, in all, 4,000 square miles.

It is worth a trip to Colorado to stand on the top of Rabbit Ear. In North Park we had found scoriaceous rock, which called to mind forcibly the thought that a volcano was not far away. In ascending Rabbit Ear it soon became apparent we were on the very cone itself. Along the sides, in great profusion, were fragments of scoria, with occasional slag-like masses. These continued to the top, where the two great ears seemed to be firmer, more like trap, though not entirely uniform, some portions weathering away much faster than others. We had no means of determining our altitude at this point, but from the snow about us (this was July 12th,) and the Alpine vegetation, it must have been about 12,000 feet. Steamboat Springs is northwest of Rabbit Ear about eighteen miles. The pass here, at this time, was completely dry, but a little earlier it is very muddy, almost impassable. On reaching the western edge of the Park range, about seven miles east of the Springs, it seemed as if we had come to a jumping-off place. Far below us we could see the Bear with its beautiful valley, green fields of oats and timothy, the little log houses of the pioneers, and to the right in the distance, nestled at the foot of this great mountain range, lay the village, Steamboat Springs. The Yampa or Bear river here runs west from Egeria Park, but at the Springs it turns south.

The mountains to the south of the Bear appear to be much lower, and differ in many respects from the Park range just to the north There is not that boldness, that ruggedness, although separated only by the narrow valley of the Bear. The student of geology could not fail to be impressed with this difference, as he stands at this point on the southern edge of the Park range. On descending the mountain but few extensive rock exposures are seen. Most, if not all, of the rocks show metamorphism, being derived from what seems to have been some kind of sandstone or argillaceous shales. No marble was noticed in this locality. On the north side of the Bear river, in the valley three or four miles east of the Springs the region is thickly covered with well rounded granitoid bowlders, some of which are ten to twenty feet through. These have come from the mountains close by on the north. The bed and banks of Fish creek are a mass of bowlders, with very little filling between them. This is a

pretty mountain stream, which has its sources in the great range just north of this valley, and joins the Bear a mile east of the Springs. Some four miles up, this creek has made for itself a wild, deep gorge or cañon, and here, in 200 or 300 yards, it falls perhaps 200 feet. In this cañon great masses of rock lie in every position and these show plainly a bedding, although the main walls of this cañon are almost vertical sheets of metamorphic rocks.

At a point some six or seven miles northwest of Steamboat Springs, at some springs we visited, the temperature of the water is said to be about 160 degrees F. The rocks are, in part, at least, very dark colored, compact and fine grained, resembling diorite. Enough has been said to show that the Park range, immediately north of Steamboat Springs, is largely metamorphic, abounding in granites, syenites and volcanic rocks. In this vicinity the valley of the Bear is from one-half mile to a mile in width. Directly opposite the village, which is almost wholly on one street on the north side of the river, is a rather lofty and rugged mountain, but for the most part the country on the south side of the Bear is much less precipitous and is not covered by timber like the mountains close on the north. The valley here has undoubtedly been the seat of an immense glacier, which was well supported from the north by great numbers of glaciers lying on the southern face of Park range.

One very conspicuous moraine lies in the village, and to improve the single straight street this moraine has been cut transversely. In the village there are four charming little creeks, all coming from the mountains on the north. Not a single creek enters the Bear river, for several miles, from the south. Opposite the eastern or upper end of the village, some 300 feet above the valley of the river, is an "onyx mine." Here a horizontal tunnel has been carried perhaps 200 feet into the side of the mountain. A cross section of this tunnel is not less than six feet square. It is perfectly dry and is wholly in what seems to be unmodified drift. The onyx is scattered through this drift in pieces varying from a cubic inch to blocks three or four feet square and eight or ten feet long. These pieces show, in many cases, unmistakable evidence of erosion or weathering, and they are so packed in with the clay and granite pebbles that we could hardly pull out small pieces from the walls of the tunnel. How extensive the

onyx deposit here may be, we could not determine, but there are some reasons for believing the material to be abundant. Its geological history, at present, is not altogether clear, but it may be assumed that all such limestone formations have been formed in caves. The cave or caves where this was formed must have been near by, for the fragments are of such shape as to show but little abrasion from ice or water. The cave seems to have been crushed by the glacier, crowded up against the side of the mountain and left there without any further disturbance. It seems probable that the scene of the action of the glacier must have been mainly lower down towards the foot of the mountain, otherwise this soft onyx would have been reduced to limestone mud. It also seems very probable that caves, in which this onyx forms or grows, no longer exist in this region, unless it might be a short distance to the west from the present mine, where heavy deposits of calcium carbonate exist and where such deposits are now forming. Where this supply of material, necessary to form the onyx and soft, limy hills, near by, was obtained, we did not discover, but there must be limestone in the mountain not far away.

At the extreme western end of this long valley, which is about one-half mile long, and a few rods west of Soda creek, is a fine spring of moderately cool water, supersaturated with carbon dioxide. This spring is in the midst of a flat area of several acres, much of which shows plainly that springs once existed almost everywhere over it, and now, only a dozen rods away, are large springs yielding an abundance of hydrogen sulphide, the odor of which may frequently be detected a quarter of a mile distant. The "soda spring," as it is called, referred to above, issues now through a round hole about one foot in diameter, in a heavy block of sandstone. The spring is covered by a neat pavilion, ten or twelve feet square, with comfortable seats around the inside. It is a general resort for campers at the springs. The carbon dioxide comes up in great bubbles and the water is delightfully acid There is no evidence at this spring that the water carries any limestone with it. Along the banks of the Bear, near by (this spring is probably ten to fifteen rods from the river), were thin, soft, shelving rocks, of what are supposed to be calcium carbonate, four or five feet in total thickness. On the south side of the river were rounded hills twenty feet or more in height and of

considerable extent; in one case an acre or more of this same soft rock, evidently formed by the springs. One spring is heavily charged with iron; another is called milk spring, soda spring, sulphur spring, etc., all within easy distance of each other. Some springs have a sort of periodic flow.

Particularly is this true of one which sounds very much like the puffing of a steamboat.

At the eastern end of the village is a spring issuing from fissures in what seems to be a volcanic rock. The water of this spring has a temperature of 108 degrees F. Close by this spring is a very neat and convenient bath house, with nice large pools for swimming. The water here is abundant, and, at first, seems almost too hot for comfort, but it soon becomes delightful. It contains a small amount of hydrogen sulphide. Seven miles northwest of the village, in a very wild and unfrequented region, we visited what are known at the Springs as the Hot Springs. Here the water has a temperature of 160 degrees F., so we were told; we forgot our thermometer at Ft. Collins. In about twenty minutes it cooked eggs for us. These springs are within a rod or two, on either side, of a delightful little mountain stream. They issue from fissures in a dark, fine-grained rock, already referred to as resembling diorite, or basalt. In one of the hills mentioned above, formed by the springs by the Bear, is a small cave. On descending into this cave, I had my first serious encounter with carbon-dioxide. It was wholly unexpected, and for a few moments I could not realize why I could not breathe. Other members of our party went into the cave, cautiously, to convince themselves that there was an unbreathable gas present. In the bottom of this cave is an incrustation of what appears to be sulphur.

There are abundant reasons for believing that the springs in and around this village are on the decline. Places where springs must have been strong and vigorous, in very recent geologic time, now show no signs of life. Such places are numerous. How rapidly such changes are taking place here now, we did not attempt to determine.

Steamboat Springs is probably a little over 6,000 feet above the sea. Every night, while we were camped at the village, water froze in our buckets, and particularly, on the morning of July 24th, so much ice was formed in our buckets and about our mess box, that, judging from like conditions at Muscatine,

the temperature must have been close to 20 degrees F. Apparently tender vegetation—beautiful wild flowers—seem to laugh at these little touches of winter, and likewise, in the Hot Springs where the water boiled eggs in twenty minutes, at least one alga grows in considerable abundance.

THE DISTRIBUTION OF LOESS FOSSILS.

BY B. SHIMEK.

It has perhaps been noted that the loess molluscs thus far reported in the literature of the subject are, for the most part, from localities in close proximity to larger streams. This fact may have suggested the thought to those unfamiliar with the modern habits and present distribution of these molluscs that the adjacent streams had in some way something to do with the entombing of the shells now found in the loess. That the loess is most richly fossiliferous near streams is generally, though not always, true. The abundance of fossils is a decidedly variable quantity. There are exposures near streams which exhibit fossils in profusion,and others which are wholly barren. On the other hand, exposures quite remote from streams contain fossils,—though in such situations a proportionately much larger part of the loess is entirely devoid of them.

This fact has sometimes led geologists to attempt to distinguish, in varying degrees, between the loess adjacent to streams and loess more remote. Whatsoever distinction may be observed in the physical character of the loess of various deposits,* no distinction can be based on the presence or absence of fossils alone. The simple fact that one deposit is fossiliferous and another is not, does not prove, nor even indicate, that the deposits were formed under wholly, or even materially, different circumstances. In the one case there are no fossils, simply because there were no shells to be buried; in the other, fossils are common because shells were abundant on the old land surfaces, where they were covered as other imperishable objects would have been covered.

*For one of the most recent discussions of the loess,with reference to its variation according to distance from streams, see Doctor Chamberlin's article in the Journal of Geology, Vol. V, No. 8, p. 795.

Fossils are more abundant in the vicinity of streams because the same species thrive, and in all probability did thrive in the past, in just such situations.

Manifestly, if we would judge of the conditions under which the fossils existed and were finally buried in the past, we must understand the conditions under which the same species exist to-day.

It has already been pointed out by the writer* that the loess-fauna of any section of the country closely resembles the modern molluscan fauna of the same section, the characteristic fossil species being, for the most part, characteristic species of the modern fauna.

During the past summer the writer made more extended studies of fossils in widely-separated loess regions; notably in Mississippi, Iowa (both eastern and western) and Nebraska, which strongly emphasize the foregoing fact. As questions of general geographical, as well as local, distribution of fossil and modern molluscs are of great importance in connection with any attempt at an explanation of the manner in which loess was deposited, the following remarks are offered as preliminary to further detailed reports upon the distribution of the loess species and of their modern representatives.

In Iowa and Nebraska, as elsewhere, land-shells form the characteristic fauna of the loess, and with two or three exceptions the same species may be found living within the borders of our state to-day.

The student who goes to the field to study the living forms in their natural environment, if his studies be sufficiently extended, will be struck by the many seeming eccentricities in distribution. He will, however, observe that our land-molluscs, as a rule, favor the regions adjacent to streams, especially the rough, rugged hills which so often border them. This fact, however, seems to be dependent upon another, equally interesting and long well-known; namely, that our timber-areas, for the most part, skirt the streams; and that this distribution of vegetation determines largely the distribution of the molluscs is shown by the fact that timber or brush-covered areas, remote from streams, are quite likely to yield plenty of shells. A few species (as for example *Succinea grosvenorii*) seem to favor open, rather grassy places, and a few others may be found among the weeds and bushes skirting

* Proc. Iowa Acad. of Sci., Vol. V, pp. 33-41.

prairie ponds, but as a rule, rough, rolling timber-areas are favored. Here an abundance of food (for nearly all are herbivorous) and more or less shade and protection are furnished by the vegatation. As we recede from the timber-bordered streams, the number of species and specimens grows less, and the writer knows, from personal experience obtained in various parts of the state, that large prairie-areas of that character may be searched in vain for any trace of a land-mollusc. In the eastern part of the state, with its more rolling, timber-covered surface, almost every locality—certainly every county—presents numerous favorable locations for colonies of snails, but as the collector crosses the state westward he finds that, in species and in specimens, the molluscan fauna grows poorer, the timber-fringed streams, or ponds and lakes, alone marking the favorable localities.

If careful observations are made even in the best of these collecting-grounds, whether in the eastern or western parts of the state, it will be found that much variation and inequality in local distribution exists. One hillside may present certain species, while the next, perhaps across a narrow ravine, will show a wholly different series, and a third near by may have none at all. A species which in one spot is the prevailing type, may, only a few rods, or even feet away, be wholly, or in part, supplanted by another. This is sometimes due to differences in the abundance of trees and vegetation furnishing food, and to other variations in the character of the surface, but often it seems to be a mere accident.

The number of individuals of any, or all, species in a given locality is also very variable. In the most favorable spots, however, especially on higher grounds, one seldom finds many individuals together. Even such species as *Zonitoides arboreus*, *Z. minusculus*, *Vitrea hammonis*, *Cochliopa lubrica*, *Succinea obliqua*, *S. avara*, etc., which may often be found in large numbers under leaves or sticks and logs in comparatively low places, usually show fewer and more scattered specimens on hillsides, etc., especially in more open places To get a good set of any species in such localities, the collector must work over a considerable area, but in doing so, he will almost invariably find individuals of several species mingled promiscuously. If he compares the molluscan faunas of the eastern and western parts of the state, he will find that as stated, the number of species and individuals in the eastern part is, as a rule, greater. He

will also find that there are certain rather striking differences between sets of some of the species taken at opposite extremities of the state. Those from the eastern part are likely to average larger in size and to be thinner-shelled, resembling more nearly representatives from the eastern part of the country, while the western forms are smaller and heavier. This is especially true of *Polygyra multilineata*, *Zonitoides minusculus*, *Succinea obliqua*, *S. avara*, and other species of the kind which are sometimes found in rather low places, but which also occur on higher grounds, especially westward. This is probably due chiefly to the scarcity of forests in the western and central parts of the state, where the rather scant groves usually consist of scattered and stunted trees, being quite different from the more vigorous forests of the eastern part. That this view is correct, is further attested by the fact that the same species of molluscs, when occurring on comparatively barren or nearly treeless areas in the eastern part of the state, usually show the characters of the western types—namely, the smaller size and sometimes heavier, or at least more compact, shell.

If the student will study the molluscs of a given region for a number of years, he will find that from year to year the abundance of the several species varies, some even running out entirely, while others unexpectedly appear. The writer has watched a number of localities near Iowa City for many years, and has found this variation often striking.

If, now, the distribution of the fossils in our loess is compared with that of the modern shells, a remarkable similarity is evident. The best collecting grounds are near streams, while the clay of the remote prairie is usually barren. Where fossils are abundant, one exposure contains species of one kind, another near by presents a new, or at least a different list, while still another has none, and the same variation which may be observed in the local distribution of the recent shells in any restricted locality, will be exhibited in individual exposures of fossiliferous loess.

In horizontal distribution the fossils show the same mode of distribution as that already noted in the modern forms. The specimens are not heaped together, but are scattered about like the modern shells, usually a number of species mingled together, but in unmodified loess invariably *not* crowded, so far as the writer's experience goes.

The vertical distribution of the fossils also conforms to the

surface distribution of the modern shells. If the loess was not deposited *in toto* at once, and this seems to be conceded, there were successive land-surfaces upon portions of which shells grew. These shells varied from time to time in numbers—some persisted during long periods, some disappeared and others took their places. If we study the vertical distribution of the fossils in the loess the same variation in the succession of species is observed. Some species occur throughout the thickness of a particular exposure, but more frequently a part of the loess is without fossils; certain species occupy a part of the deposit,—while above or below them are other species,—as though the varying generations of surface species had been successively buried in the deposit. The number of specimens upon any one of the successive land surfaces was not very great even in richly fossiliferous loess, for if we draw lines approximately parallel to the present surface to represent the successive surfaces, we will find that in any one of them but few fossils occur.

Where depauperation or variation in size is noticeable in the fossils, it will be found that it takes place in the direction of the western modern forms. For example, while the common modern *Polygyra multilineata* at Iowa City is large, the common fossil form is small,—but the small modern and the large fossil forms are also occasionally found,—but not respectively with the preceding forms. On the other hand, at Council Bluffs and Omaha, the modern shells of this species are usually small, like those of the loess, though both fossil and modern shells of the large type occasionally occur. Thus the fossils of this species, from the eastern part of the state, resemble both the fossil and modern shells from the western part. *Succinea avara* is another example. The small typical form is common in the loess at Iowa City, but the modern shells are not frequent, occurring always on more or less wooded hillsides,—while westward the type is the common modern form.

In both the loess in the east and the west* *Sphyradium edentulum alticola, Pyramidula strigosa iowensis,*† *Succinea grosvenorii,*—forms belonging now to the dry western plains,—are

*The loess herein designated as "eastern" is that of eastern Iowa,—the "western" being that of western Iowa and eastern Nebraska.

†This form has heretofore been reported as var. *cooperi* which lives abundantly in the far west, but Pilsbry regards it as extinct and distinct, and has described it under the name *iowensis*. All living forms of *strigosa* belong to the high, dry regions of the west. Neither of these species was found at Council Bluffs, but both are found in the loess of Nebraska. *Sphyradium* was formerly included in *Pupa*.

quite common. Their presence, together with that of the "depauperate" forms, when considered in connection with the entire molluscan faunas of the eastern and western parts of the state, suggests a climate even drier than that of the eastern part of the state, and a surface less abundantly timbered. Certainly both modern and fossil faunas unmistakably show* that the conditions in the eastern and western parts of Iowa, during the deposition of the loess were approximately included within the bounds of the present extremes presented by these regions, and that any attempt to drag into the discussion of this subject, conditions either of a glacial climate or of frequent and widespread floods and inundations, or of any excess of moisture, is gratuitous.

The conditions which cause the "depauperation" of our shells exist more or less all over Iowa to-day, especially westward, and yet we do not have a glacial climate. If the molluscs of the loess be used as an absolute measure of the amount of moisture occurring during loess times, then we must conclude that Iowa was without streams, for practically no fluviatile molluscs occur in the loess, and that there were but few ponds in which aquatic molluscs found a favorable habitat, for even aquatic Pulmonates are rare in the loess,† the number of terrestrial forms being out of all proportion to that of the aquatic forms.

During the past summer the writer collected several thousand specimens in the loess of Mississippi and western Iowa, and among them all there were not a half-dozen aquatic shells. A list of the modern shells of Iowa shows a large number of aquatic species; yet few of these occur in the loess. There is also among the modern terrestrial forms a large number of those which occur only in very damp places, and these, too, are almost wholly missing from the loess. The writer is well aware that many of the forms found in the loess are often referred to as aquatic or "semi-aquatic," or at least as favoring very wet situations. But evidence of this character has been furnished largely by those who are familiar only with the molluscan fauna of the eastern part of the country where the amount of rainfall is much greater, and where surface conditions are not the same as in western Iowa and Nebraska; or it has come from so-called "closet naturalists."

*See also the writer's paper in Proc. Iowa Acad. Sci., Vol. V, particularly p. 42.

†For more detailed comparison see writer's paper (Ibid.) pp. 43 and 44, and the discussion preceding.

Now, the "closet-naturalist" has done abundant harm in this as in other branches of science. Too remote, often, from the phenomena under discussion, or too dainty to soil his fingers with the toil and the exposure of field-work, he has passed judgment upon the habits of forms which he knew only from material submitted by mail; or still worse, he has taken the work of others and, not appreciating the significance of the facts so borrowed, has distorted them to do menial service in the encouragement of some pet notion.

In the particular case in hand, no distinction has been made between the habits of the "depauperate" varieties and the larger types of the same species, and too often the habits of one species have been confused with those of another, of the same genus, or even family,—a mistake most frequently made with the Succineas. Again, the universality of certain species,—their adaptability to varying conditions,—has been overlooked. *Zonitoides minusculus*, *Bifidaria pentodon*, *B. contracta*, *Succinea avara*, *S. obliqua*, etc., frequently occur in low places,—and then often in great numbers,—but they are also found scattered over comparatively dry hillsides at considerable altitudes,—and some of these species in such places develop the "depauperate" type,—that is, they average smaller in size.

To show the preponderance of strictly terrestrial forms in the loess, the writer calls attention to the fact that in the collections made last June, at Natchez and Vicksburg, Miss., and numbering over thirty species and nearly 4,000 specimens, there is not a single aquatic form. And, furthermore, every species which was collected in the loess of that region has been found, by the writer, living upon the high bluffs and hills in and near Natchez, or upon hillsides at considerable elevations in other parts of the south, notably in northern Alabama, Georgia, and Tennessee.* At Natches, the most common living species is *Succinea grosvenorii*, and this crept upon the bare surfaces of the loess clay which, at the time of the writer's visit, had been baked by the hot summer sun of the south, during a period of drouth lasting more than six weeks. Moreover, several scores of specimens which had been carried about in the sun all day long in a box containing loess dust, and hence

*It is also a significant fact that of all the living species found on the hills and bluffs of Natchez, only two *Leuchochila fallax* and *Polygyra texana* were found in the loess of the region, only a single specimen of the first and two of the second were not collected in the loess of that region. The former is not uncommon in the loess of the north, while the latter is not known from the loess, at least to the writer.

were subjected to extremely desiccating conditions, were found after this experience, creeping about in their prison, seemingly perfectly contented. Yet we are sometimes told that the Succineas are all "semi-aquatic," or that they must have an abundance of moisture. Another illustration, equally striking, is furnished by the writer's experience and observations at Council Bluffs during the past summer and autumn. It had been purposed to make a detailed comparative study of the fossil and modern molluscan faunas of that vicinity, but the work was somewhat interrupted by the severe September rainstorms and November blizzards. Nevertheless interesting and valuable data were obtained, and are here briefly presented.

More than 4,000 fossils were collected, and their distribution was carefully noted, in twenty exposures, beginning at the eastern extremity of Fifteenth avenue in Council Bluffs, thence along the bluffs to the high school,—a distance of about one mile,—and in Fairmount park, along its winding roads, for about half a mile eastward. The location of the several exposures is shown on the accompanying map. A list of the fossil species, together with the number of specimens collected in each exposure, is given in the appended table.

If this table is studied it will be observed that of the thirty species collected, not one is aquatic.

For purposes of comparison the writer made collections of recent shells in seven distinct localities in practically the region containing the above-noted exposures. These localities are here discussed in detail, the letters designating them being also employed to mark them on the map.

A. A grassy, treeless hillside in Fairmount park, nearly opposite Eleventh avenue, and at an altitude of from 175 to 245 feet above the river valley.* Species 8, 11 and 29† were found living.

B. A grassy, treeless slope just above the exposure marked N. Altitude about 200 feet. Species 8, 10, 11, 15 and 29 were found.

C. Near the Tenth avenue entrance to Fairmount park, at an altitude of about ninety feet above the river plain. Species 8, 10, 11, 21, 22, 27 and 30 were found. A few stunted and scattered Bur-oaks grew on the slope immediately above this point.

*The altitudes were all determined by barometric measurements taken from the nearest north and south street on the river flat.

†The numbers refer to the species named in the table of fossils.

D. A brush-covered hill just above the exposure marked E. Altitude about 170 feet. A small collection containing species 11 and 30 was made.

E. A locality in the northwestern part of Fairmount park, on a northerly slope, somewhat grassy, but with shrubs and a few Bur-oaks, nearly opposite Eighth avenue. Altitude 280 to 300 feet above the valley. Here we found species 3, 8, 11, 13, 18, 19 and 27, and also one specimen of *Bifidaria procera*, the only recent species found in the tract examined, which was not found in the loess. This locality is just over the brow, on the north or leeward side* of one of the most exposed ridges in the area under consideration.

F. A part of the same slope immediately below *E*, and fifty to 100 feet lower. Here the forest is better developed and contains a number of species of trees. Species 8, 11, 18, 19, 22, 25 and 28 were found.

The points *E* and *F* are on the same very steep slope, but *E* is much more exposed and drier, *F* being more protected by its forest covering and position. A comparison of the species from these points is therefore interesting. Species 3 and 13, while common at *E* were not found at *F* the lower point. While 18 was common at *E*, only one specimen was found at *F*. Number 19 is also more common at *E* than at *F*. These facts are of interest when we seek to determine the extent to which shells are likely to be washed down even very steep slopes. Numbers 8 and 11 were about equally abundant, while numbers 22, 25 and 28 were found only at *F*.

G. The banks and grassy slope near and above the exposure *M*. This yielded species 3, 13, 21, 24 and 27.

It will be observed that species 1, 3, 4, 5, 6, 7, 9, 12, 14, 15, 16, 17, 20, 23 and 26,—or just one-half the total number,—are not contained in the collections of modern shells cited. The number of individuals of the surface species is also comparatively small. Of these numbers, 1, 16 and 23 are extinct in that section of the country, number 1 occurring eastward, number 16 westward, and number 23 being entirely extinct.

The modern fauna of the more or less exposed hills at Council Bluffs is much poorer in species and in specimens than the

*The prevailing winds during the seasons of the year when the snails are active, are from the southwest.

fossil fauna of the underlying loess; but every species thus far discovered in the loess of Council Bluffs occurs more or less abundantly (certainly as abundantly in some places as in any part of that loess) living along the Missouri river, especially on the western, more heavily-timbered bluffs. All the species above mentioned, as not found in the surface collections, have been collected by the writer on the banks and hills, along the Missouri, between Omaha, Neb., and Hamburg, Iowa; usually not in very damp places, but living under the conditions which prevail along those bluffs. Even *Polygyra multilineata* is there often found on high grounds, and then appears as a stunted form, like that which is common in the loess.

The loess-fauna, of Council Bluffs, is thus not only wholly terrestrial, but, with the exceptions noted, is almost identical with the modern upland fauna of the same regions. Surely no conditions of excessive moisture prevail in that region to-day. Yet a recent writer,* referring to the loess of the Missouri region, says: "In the Bluff loess more than nine-tenths of the total number of individuals belong to species that are found only in unusually damp situations. The species having an optimum habitat that is not excessively moist have not been observed to occur abundantly in the Bluff loess."

Another interesting fact noticeable in the exposures of loess, at Council Bluffs, is the occurrence of the great majority of the fossils in a more or less distinct stratum which varies (so far as observed) in altitude from about eighty to at least 200 feet above the river-valley, and which follows in general the contours of the present surface, but with a less convex curvature. (In exposure N it seems to be a continuation of the shell-bearing layer in E, yet it is at least 100 feet higher. In exposure M it drops about eighty feet in a block.) Its limits are not sharply defined above or below, and it varies in thickness from about six to at least twenty feet. Overlying it is a deposit of more or less laminated loess-clay, which is usually non-fossiliferous, and which varies from a few to more than thirty feet in thickness. When fossils occur in this upper stratum, they are few in number and widely scattered.†

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*C. R. Keyes—Am. Jour. of Sci., (4), Vol. VI, p. 304.

†At the base of the bluff in exposure K, what seemed to be a second shell-bearing layer was observed about seventy-five feet below the main fossiliferous band. The section, however, was more or less obscured, and the mass may have slipped from the bluff above. The fossils in column K, in the table, are from this stratum. It will be observed that they are ordinary forms which are abundant in the main shell stratum.

The presence of this shell-bearing stratum suggests that for the period during which it formed the surface soil, and while it was slowly accumulating, the conditions in this particular locality were more favorable to the growth of land-snails than now. There was, probably more vegetation, and hence the surface was not so frequently storm-swept as at present. This does not necessarily signify that general climatic conditions were different, but that these particular banks or bluffs were more heavily timbered, with the Missouri river, probably flowing at its base, its surface conditions being similar to those of many timbered hills and knolls between Omaha and Nebraska City, west of the Missouri.

It is interesting to note that between Iowa and Nebraska, the Missouri river now flows along the western side of its broad valley, and that the adjacent western bluffs are more heavily timbered and contain all the living species of molluscs herein recorded, with the exception of Nos. 1 and 16, while the more remote eastern bluffs are more barren and rugged. The shell-bearing band may simply represent the period during which the river in its shiftings occupied the eastern part of the valley.

The foregoing facts lend support to the æolian theory of the origin of the loess, as is shown by the following considerations:

First.—The general manner of distribution of the modern and fossil molluscs is essentially the same, this fact indicating that they were not carried by waters, but were quietly buried in dust. Had they formed a part of river-drifts, they would be more frequently heaped together,—not scattered as we find them in the loess —and fluviatile shells would be more or less intermingled. Moreover in many years' experience in dredging in ponds and streams. the writer has seldom seen a land-shell which had been carried with the finest sediment into ponds or lakes though such shells are sometimes found in sand and other coarse material. Currents of water which could carry most of the shells now found fossil, would also carry coarser material than that which makes up the loess.

Another fact which bears out this conclusion is the presence of opercula in fossil shells of *Helicina occulta* in the northern loess and *Helicina orbiculata* in the southern loess. As the operculum so readily falls from the decaying animal, it would scarcely remain in place if the shell had been transported any distance.

Second.—The occurrence of fossiliferous loess chiefly in the

vicinity of streams is consistent with the theory of loess-formation presented by the writer before this academy.*

Plants, and especially forests, develop chiefly and primarily along streams. This creates conditions favorable to land-molluscs, and at the same time forms a trap for the dust, carried from adjacent, more barren regions. The occurrence of loess in the eastern part of Iowa, chiefly along the border of the Iowan drift sheet, may also be explained on the same ground. After the melting of the ice, the terminal moraines offered the first lodging-place for plants. Here, forests early developed, and the conditions for entrapping the dust from adjacent, less-favored territory, which was probably dry during a part of the year, were here first developed We are in the habit of describing the lobed ridges of loess-regions as characteristic of loess topography, yet they are quite as much characteristic of some drift-areas; for example, along the Big Sioux river in Iowa and South Dakota. In eastern Iowa the surface of the loess is largely shaped by the underlying moraines, which first presented conditions suitable to the deposition of the loess, and where, consequently, the deposit is best developed. The loess at Natchez does not show this "loess-topography in the same degree"

Third. — The depauperation of some forms of shells, and the presence of others which are normally inhabitants of dry regions, suggest a climate sufficiently dry that, during a part of the year, at least, clouds of dust could be taken up by the winds.

Fourth. — The overwhelming preponderance of land-snails in the loess must always be borne in mind. This, however, does not prove that the loess regions were entirely devoid of lakes and streams, but rather that the loess proper was deposited chiefly upon higher grounds, for, if by any agency fine material was uniformly deposited over all of Iowa to-day, covering the successive generations of our present molluscan fauna, there would be a much greater proportion of aquatic and moisture-loving species than we find anywhere in the loess.

Fifth.—The amount of material carried by the winds need not have been so great as is sometimes assumed. The estimate made by the writer† for the rate of deposition for eastern loess (1 mm. per year), and that made by Keyes‡

*Proc. Iowa Acad. Sci., Vol. III, p. 82 *et seq.*

†Proc. Iowa Acad. Sci., Vol. III, p. 88.

‡Am. Jour. of Sci., (4), Vol. VI, pp. 301-302.

for western loess (one-tenth to one-fourth of an inch) would be sufficient to form most of these deposits respectively in the 8,000 years, usually computed, since the recession of the glaciers.

The objection made by Doctor Chamberlin* that "the eolian deposits are measured, not by the quantity of silt borne by the winds and lodged on the surface, but by the difference between such lodgment and the erosion of the surface," is met, at least in part, by the theory offered, for it is a well-known fact that timbered areas, even when very rough and with abundant slopes, are scarcely eroded by even the most violent precipitation of moisture. Professor Udden's recent admirable report† also bears on this question, and should not be overlooked by the student of loess-problems.

Sixth.—No distinction can be made between the origin of eastern and western loess. The finer quality and lesser thickness of the former rather suggest that there had been more moisture (*i. e.*, a shorter dry period during each year) and, hence, less dust; that the winds were less violent, and that there were greater areas completely covered with vegetation, this resulting in the necessity of transporting dust much greater distances, which would therefore be finer.‡

It should be borne in mind that the above noted differences between the regions in question actually exist to-day. There is more rain,—there are larger areas closely covered with vegetation, and less violent winds prevail in eastern Iowa and eastward,—and considering the position of mountain chains and seas, the same differences must have existed for a long time. That they did exist, during the deposition of the loess, is also indicated by the proportionately somewhat larger number of species in the eastern loess which prefer or require moist habitats. But the fauna of the eastern or Mississippi river loess is essentially a terrestrial fauna. The great fluviatile groups, now everywhere common in the streams of eastern Iowa, are wanting in the loess, and the few fossil aquatic species are such as to-day prefer ponds, and are often found even in those which dry up during the summer.

It may again be emphasized that the fossils show no greater difference, between the surface conditions which existed during the deposition of the loess of the eastern and western parts of

*Jour. of Geol., Vol. V, p. 801.

†The Mechanical Composition of Wind Deposits. 1898.

‡See Udden, *l. c.* pp. 56, 57 and 67.

Iowa, than exists to-day between the surface conditions of the same regions. This fact is irrefutable, and must not be overlooked in any discussion of the conditions under which loess was deposited.

TABLE OF SPECIES.*

		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
1	*Helicina occulta* Say	5	55	210	5	5	81	17	89	9	14	3	12	14	96						
2	*Vallonia gracilicosta* Reihn	10	157	12		1	8		21		3	1	1	1	45	1			1		
3	*Vallonia parvula* Sterki	2																		1	
4	*Vallonia perspectiva* Sterki	3	12																		
5	*Polygyra multilneata* (Say) Pils		6	70	2		16	4	7		6	1		2	3	1		2		1	1
6	*Polygyra profunda* (Say) Pils			†																	
7	*Polygyra hirsuta* (Say) Pils	1		‡																	
8	*Polygyra leai* (Ward) Pils	4	21	63	1	1	17	2	14		4			1	12			?			
9	*Strobilops virgo* Pils	8		3			2		1	1					1						
10	*Leuchochila fallax* (Say) Try		2																		
11	*Bifidaria armifera* Say) St	35	280						3	1											
12	*Bifidaria contracta* (Say) St	5																			
13	*Bifidaria holzingeri* (Sterki) St								1												
14	*Bifidaria curvidens* (Gld.) St	1																			
15	*Bifidaria pentodon* (Say) St												2	4	12			2	3	2	
16	*Pupa blandi* (Morse) Binn	11	127			1															
17	*Vertigo bollesiana* Morse												10	3	28						
18	*Cochlicopa lubrica* (Müll) P. & J.	1	4	27	1	1	12		22	1	2				18						
19	*Vitrea hammonis* (Ström) P. & J.	2	3	10			10	1	3			1	1		1						
20	*Vitrea indentata* (Say) P. & J.			1																	
21	*Conulus fulvus* (Drap.) Müll						1		1	1				1	5						
22	*Zonitoides arboreus* (Say) St	3	4	21			4	2	12						10			3			
23	*Zonitoides shimekii* (Pils) P. & J.‖															2		1		2	
24	*Zonitoides minusculus* (Binn.) P. & J.	1	2	6			1		3			1			7						
25	*Pyramidula alternata* (Say) Pils		4	19		1	4	1	11	3	2				1						
26	*Pyramidula striatella* (Anth.) Pils	1	20	46	3		21		28	2		1	4	4	24	2			1	1	
27	*Helicodiscus lineatus* (Say) Morse	6	18	6		1	7		5						13						1
28 29	*Succinea obliqua* Say¶ *Succinea grosvenorii* Lea	3	180	935	8	10	235	58	279	8	72	21	12	5	250	4	2	15	3	15	3
30	*Succinea avara* Say	15	11	16			7	1	11		2	1	3	2	14	4	2		3	5	
31	Egg of a land snail						1														

*The nomenclature of Pilsbry and Johnson's recent *Catalogue of the Land Shells of N. Am* is here employed. As there are some departures from former usage, the changes are here noted:

Species 2, 3 and 4 were formerly included under *V. pulchella.*

Species 5 and 6 were referred to the genus *Mesodon*, and 7 and 8 to *Stenotrema.*

Species 9 was included under *Strobila labyrinthica.*

The species of *Leuchochila* and *Bifidaria* were included in *Pupa.*

Species 18 was called *Ferussacia subcylindrica.*

Vitrea, *Conulus* and *Zonitoides* were formerly placed in the genus *Zonites*, and No. 19 was called *Zonitoides radiatulus.*

Pyramidula was formerly *Patula.*

Succinea grosvenorii was called *S. lineata.*

†One specimen of *P. profunda* was found by the writer in exposure C (since considerably altered) in 1890.

‡Three specimens of this species were collected in exposure C in 1890.

‖The writer formerly regarded this as a form of *Zon. nitidus.* Mr. Pilsbry, however, regards it as distinct, and in deference to his opinion his name is retained.

¶The form of *S. obliqua* which occurs most commonly in the loess is the narrower, smaller form with more extended spire, such as is not uncommon (living) in Iowa and as far east as Indiana. As it is difficult to distinguish between some forms of this and *S. grosvenorii*, the two species are not here separated, as more time for careful comparison of the large sets will be required.

NOTES AND EXPLANATION OF MAP.

THE EXPOSURES ARE REPRESENTED BY HEAVY LINES.

Exposures A B and C. These were cut out of the same ridge in street-grading. The shell-bearing stratum shows well on the east, north and

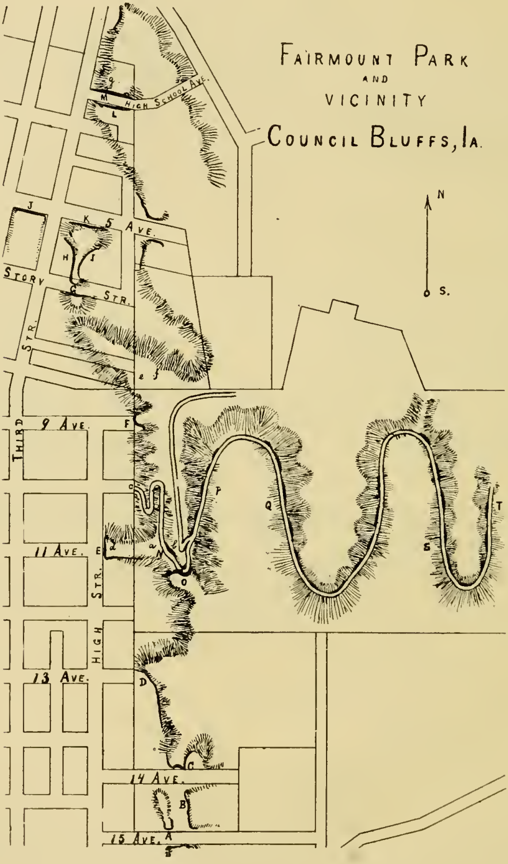


FIGURE 2.

west sides of *C*. It is about twelve or fifteen feet thick. Above it there is a layer of clay about fifty feet thick and almost entirely devoid of fossils.

Exposure D. The shell stratum is not so rich in fossils as in *C*. Above it there are fifteen or twenty feet of clay, in which a few Succineas were found. In the clay below the shell stratum there are several distinct, but irregular, bands of lime nodules,—some very large.

Exposure E. Very similar to *D*, but with only one band of nodules.

Exposure F. Fossils are very abundant in the shell stratum, which can here be traced for three or four rods. The shell-less loess above is eight or ten feet thick.

Exposures G, H, I, J and K. These exposures were all formed from the same ridge, by deep cutting and grading. The shell stratum is distinct in all of them, and, as in all other sections, it follows in general the contour of the surface. It varies in thickness here from six to twenty feet. It is by no means equally fossiliferous throughout.

Exposures L and M. These were formed by the grading of High School avenue. The street slopes westward from the high school, and drops about sixty feet in a block. On the north side the shell stratum is nearly parallel to the street grade, and but little above it. On the south side it dips below the street about half-way down the slope.

Exposures N, O, P, Q, R, S and T These are all exposures along the road which winds eastward from the Tenth avenue entrance to Fairmount park At *N* the road is about 185 feet above the river valley, and the shell stratum (which is here very rich in fossils), extends about three feet higher. It dips down toward the west at such an angle that it would connect with the shell stratum at *E*, which is about 100 feet lower. The same layer may be traced, more or less indistinctly, to *O*, where there is a cut about twenty feet deep. The shell stratum rises to about eight feet above the roadbed (here about 200 feet above the river valley), but fossils are not abundant. The remaining exposures along this road are formed by the road cutting the smaller lateral lobes of the greater ridges. The letters apply to the extent of road from bend to bend, not to individual exposures. At the southern bends in the road are the high points, the road sloping down to near the bases of the ridges to the north. Fossils are found in most of the little exposures (which, in but few cases, exceed fifteen feet in height) along the road, but they are nowhere as abundant as in some of the exposures along the bluff fronts. The exposures which are represented on the map, but not lettered, are non-fossiliferous.

THE IOWA LIVERWORTS.

BY B. SHIMEK.

Among the groups of plants hitherto neglected by Iowa botanists, the liverworts are by no means the least interesting. A few of the large thalloid species have long been familiar objects to botanists working in other fields, but the general lack of economic importance of the group, and the habits and small size of most of the species, no doubt account for the fact that they have attracted less attention than they deserve.

In general, the liverworts prefer moist places. They may

be found upon mud-flats, upon dripping rocks, on moist limestones and sandstones, on the bark of trees, on old logs, in tangled mats of moss, and other similar habitats. But not infrequently they flourish on rocky ledges and sandy or clayey tracts, which are dry and barren during the greater part of the summer. Their power of re-juvenation, however, almost equals that of their near kin, the mosses, and moisture almost instantly revives them,—a fact of much interest to the student of these forms, for dry, unsightly material collected during the most unfavorable seasons of the year, may be rendered fit for study in a few moments.

The following notes on twenty-one species are offered not as a complete and exhaustive report on the *Hepaticæ* of Iowa, but rather as an introduction to this, in Iowa much-neglected, group, with the hope that interest in it may be aroused, and the way paved for a full account of our species and their distribution,—for the list will no doubt be materially increased.

Although its nomenclature is not always strictly correct, the sixth edition of Gray's Manual is followed for convenience, because of its general use.

Unless otherwise stated, the material upon which this report is based, is deposited in the herbarium of the State University, and was personally studied by the writer.*

Unless special credit is given, the specimens were collected by the writer, Mr. T. E. Savage assisting at Wildcat Den, Muscatine county, and with Mr. P. C. Myers on Muscatine Island, Louisa county.

Order JUNGERMANNIACEÆ.

Frullania virginica Lehm. On the bark of trees, usually near the base, on low grounds, Muscatine Island, Louisa county; not common.

F. eboracensis Lehm. On the bark of trees, near base, in Johnson and Louisa counties, and on both bark of trees, and sandstone, in Wildcat Den, Muscatine county; very common; also reported from Story county by Bessey.†

F. æolitis Nees. On sandstone, in Wildcat Den, Muscatine county; not common.

F. squarrosa Nees. Common on limestone bluffs at Iowa City, and at Ft. Dodge.

*Prof. L M. Underwood kindly assisted in a few of the earlier determinations.

†Bull. Ia., Agric. Coll., Nov., 1884.

Porella pinnata L. Thus far collected only in Jackson county, in 1896.

P. platyphylla Lindb. Very common on mossy banks, etc., at Iowa City, Mason City and Ft. Dodge; also near Decorah (*P. C. Myers.*) Reported from Story county by Bessey (*l. c.*).

Ptilidium ciliare Nees. On rotten logs; Iowa City; not rare.

Lophocolea heterophylla Nees. Very common on mossy banks near Iowa City.

Chiloscyphus polyanthos Corda. Common in moss on moist banks, rotten logs, etc.; Iowa City, Ft. Dodge, and Wildcat Den, Muscatine county.

Jungermannia ventricosa Dicks. On moist banks; in moss at Iowa City and Ft. Dodge, and on *Anthoceros* in Muscatine county, along the Cedar. Also collected at Iowa City by Miss Linder.

Blasia pusilla L. Abundant on dripping rocks at Wildcat Den, Muscatine county.

Order ANTHOCEROTACEÆ.

Anthoceros lævis L. On wet clay-banks, Johnson county. Also collected by Miss Linder. Not common. Also reported from Story county by Bessey (*l. c.*).

A. punctatus L. On low, wet banks in Muscatine county, along the Cedar river.

Order MARCHANTIACEÆ.

Marchantia polymorpha L. Usually on rather moist banks and slopes,—sometimes on hard-beaten soil and cinders, as along the streets of Iowa City. Common at Iowa City, Mason City, and Forest City. Also, Emmet county (*R. I. Cratty*) and Decorah (*P. C. Myers*). Reported from Story county by Bessey (*l. c.*).

Conocephalus conicus Dumort. Very common on moist banks at Iowa City, and not uncommon in Muscatine and Louisa counties. Also at Decorah (*P. C. Myers*). Reported from Story county by Bessey (*l. c.*).

Grimaldia barbifrons Bisch. Common on rocky banks and bluffs; sometimes in very barren places. Johnson, Linn, Muscatine, and Lyon counties.

Asterella hemisphærica Beauv. Not rare at Iowa City, on mossy, rocky banks, etc.

Lunularia vulgaris Raddi. Introduced. Formerly common in the hothouse at Iowa City. Never fruiting here.

Order RICCIACEÆ.

Riccia frostii Aust. Not common on mud-flats on Muscatine island in Louisa county.

R. lutescens Schwein. Very common on mud-flats on the Mississippi bottoms below Davenport, and on Muscatine island in Louisa county.

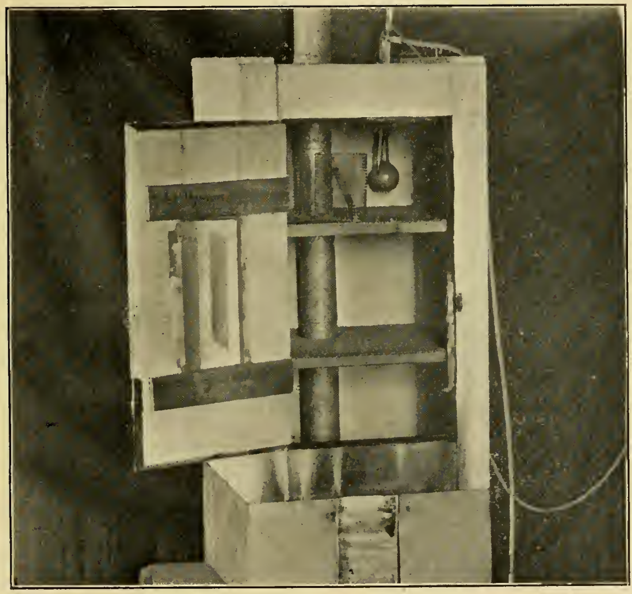
R. fluitans L. Common in ponds and on mud at Cedar Rapids, Forest City, near Davenport, and on Muscatine island in Louisa county. Also in Emmet county (*R. I. Cratty*).

A SIMPLE INCUBATOR.

BY L. S. ROSS.

No claim of originality is made in the presentation of the description of the simple apparatus used by me as an incubator. The idea, so far as I know, originated in the mind of Mr. W. D. Frost, assistant instructor in bacteriology in the University of Wisconsin.

The incubator consists of a drygoods box, lined inside and out with asbestos paper, set on a galvanized iron base, and divided by wire netting into a convenient number of shelves. Heat is obtained from a rose burner, and is regulated by a thermostat made in the laboratory. The box I used is thirty-three inches long, nineteen inches wide and twenty-six inches from front to back. The cracks were stopped with rags and then the asbestos paper was pasted on the wood. A door was cut in the front, a window in one side and one in the door. The door is 25x13 inches; the side window is 9x8 inches, and the one in the door is 12x6 inches. A galvanized iron pipe, three inches in diameter, open at the lower end and closed or opened at the top by a circular cut-off, passes through the box from the base and projects six inches above the top. A hole, three and one-half inches in diameter, is cut through the center of the lower end of the box and the iron base, leaving only one thickness of asbestos paper between the chamber containing the burner and the lower compartment of the incubator. This hole may be closed by a galvanized iron slide. The incubator is divided into three compartments, the lower two of which are



A Simple Incubator.

each ten inches high and the top one eleven inches, the shelves being of one-fourth inch mesh galvanized iron wire netting.

In the top compartment is the heat regulator, which consists of a 100 cc. flask for a bulb, and a one-fourth inch glass tube with a double bend, to contain liquid and to receive the gas. One end of the tube passes through a rubber stopper into the flask, while the other end receives a smaller tube, reaching down toward the mercury in the lower curve. On the side of the small tube is a capillary opening, cut with a file, to permit a flow of gas when the opening at the end of the tube is closed by the rising mercury. The liquid used in the bulb is a solution of calcium chloride, and in the bend of the tube is mercury. Other liquids may be used.

The incubator was used last spring in class work in bacteriology and gave good satisfaction. The greatest variation in temperature observed was not over 2½ degrees, and this only when the room became quite cold. The usual variation was not over 1½ degrees. Experiment shows that the temperature in the incubator increases from the lowest shelf to the highest, if the burner is placed under the opening of the pipe, or near it; but if the burner is near the front of the incubator, or under the opening in the center, the temperature is nearly equable throughout.

BURIED LOESS IN STORY COUNTY.

BY S. W. BEYER.

The Iowan till is not known to be present in Story county. The trend of its southwestern margin which crosses Johnson, Iowa, Tama and Marshall into Hardin county, if maintained with reasonable constancy, would carry it safely beyond the confines of the county. The loess, the silty apron of the Iowan, although suspected to be present on account of the geographic position of the area and of certain topographic contours which are decidedly loess-like in character, was not recognized certainly until during the present field season. The loess is now known to appear at numerous points along the flanks of the deeper cuts in Indian Creek and Collins townships, in the

southeastern corner of the county, near the limit of the Wisconsin drift, and there are occasional exposures in Franklin and Washington townships, along the tributaries of the Skunk river and Squaw creek, in the west central portion of the region. It is to the latter occurrence that it is desired to direct attention.

The best exposures may be viewed on sections 5 and 34, in Washington township, along Clear and Walnut creeks respectively.

The Walnut creek section shows:	FEET.
Drift, yellowish above, bluish below (Wisconsin).....	20
Loess, sandy below..................................	20
Clay, blue with much coarse gravel...........	exposed

The loess is silicious throughout and the upper four feet is distinctly joined and stained a faint yellow-brown along the joint planes. It grades downward into a massive, structureless, pale blue clayey silt which contains, in places, an abundance of root casts, wood fragments and black, Carbonaceous spots and emits a distinct swamp like odor. The entire deposit is highly calcareous and carries a rich gastropod fauna. Prof. B. Shimek identified the following forms, the majority of which are strictly terrestrial.

Zonitoides shimekii, (Pilsbry) P. & J.
Sphyradium edentulum alticola, (Ingersoll) P. &. J.
Pupa muscorum, *L.*
Bifidaria pentodon, (Say) Sterbi.
Vertigo ovata, Say.
Conulus fulvus, (Mull).
Polygyra multilineata, (Say) P. & J.
Pyramidula striatella, (Anth.) P. &. J.
Vallonia costata, (Mull) Sterbi.
Succinea lineata, Binn.
Succinea avara, Say.
Limnaea humilis, Say?

Loess concretions are relatively scarce and are diminutive in size. The deposit shows no signs of oxidation or leaching where the drift covering is thick; but where the covering is so far reduced as to afford imperfect protection from the weathering agents, both leaching and oxidation may be noted, and here, alone, are lime concretions to be found. It is obvious that little or no alteration took place prior to the deposition of the overlying drift.

The outcrop along Onion creek is an almost exact duplicate of the Walnut creek section. The drift mantle is thinner, and from two to five feet of loess has been stained to a yellowish buff, and loess concretions are more in evidence, thus attesting to the greater progress made in leaching. Here, again, the upper portion is distinctly jointed, while lower the deposit is apparently structureless. Gasterpod shells abound throughout, but only two species, not listed previously, appear—

Helicodiscus lineatus, (Say) Morse, and

Planorbis bicarinatus, Say,

both of which are terrestrial forms.

In connection with these deposits of buried loess, certain arenaceous to silty gray-brown deposits, remarkably homogeneous and devoid of pepples and bowlders, border some of the larger streams and are perhaps worthy of special mention. They are discussed here with the hope that they may throw some light on the process of loess accumulation. These highly-siliceous deposits flank the Skunk and the Squaw; are noticeably present along the lower course of Indian creek, but are more in evidence along the eastern margin of the Skunk river valley, below Bloomington. The deposits attain a maximum thickness of from three to five feet on the brow of the bluffs, thin rapidly inland and are scarcely recognizable more than a mile from the bluff scarp. These deposits are responsible for the heavy, sandy roads along so many of the streams in the Mississippi valley and are shunned alike by the teamster and the bicyclist. They are often known, locally, as "White Oak Soils," because that very well known and desirable species of oak finds in them a congenial host. The deposits are thoroughly oxidized and leached and appear to be wholly devoid of structural or bedding planes. The coarsest materials which enter into their composition are found nearest the flood plain, and the size of the grain diminishes gradually as the deposit feathers out away from the river. The source of the materials and the transporting agent are not difficult to apprehend. The process of accumulation is going on to-day. The wind, sweeping across the broad flood plain, gathers up such material as can be transported and moves it toward the restraining bluffs. Perhaps only the very finest materials are given continuous passage for any considerable distance. But through successive short excursions, the coarser silt-particles

and even fine sand-grains eventually reach the brow of the bluff and are deposited in the reverse order of their fineness*. The position of these deposits is determined, essentially by the surface contours. The wind, crossing the valley, impinging against the hill's flanks, is deflected upward, and, coming in contact with the still air above, loses velocity, and, being unable to carry its load further, deposits it over the brow of the hill. In this location its position is reasonably secure, though the entire assemblage of deposits possesses the proclivities of the sand dune and may progress bodily inland. This process of wind transport and accumulation of materials may readily be witnessed. During early spring and late autumn, when large tracts of bottom land are unprotected by vegetation, dust storms are common and, often during a single "blow," a measurable deposit is accumulated. If this be true now, how much greater must have been the efficiency of the winds, which blew across the mud flats, before vegetation had time to reclaim the valleys, so recently vacated by the Wisconsin ice?

The prevailing winds for central Iowa during spring and fall are from the west and hence the greater accumulation of æolian deposits on the eastern flanks of the streams.

These deposits are worthy of more than passing notice, when viewed analytically, on account of their striking similarity, in many respects, to the loess. Structurally, texturally and in composition and distribution, there is a remarkable resemblance. Both are essentially devoid of stratification planes, possess a uniform, open texture, are highly siliceous, being composed chiefly of silt and fine sand, and appear to be genetically related to the chief watercourses, along which they attain their maximum development. True, the loess is usually highly calcareous, but this may readily be referred to a difference in the condition of the materials drawn upon, and

*A most luminous and helpful discussion of wind erosion, transport and deposition, will be found in Professor Udden's memoir, entitled "The Mechanical Composition of Wind Deposits," published by the Lutheran Augustana Book Concern, of Rock Island, Ill., 1898 The subjoined table gives the approximate maximum distances over which quartz fragments of different dimensions may be lifted by moderately strong winds in single leaps.

Gravel (diameter from 8–1 mm.)	A few feet.
Coarse and medium sand (Diam. 1—1-4 mm.)	Several rods.
Fine sand (Diam. 1-4—1-8 mm.)	Less than a mile.
Very fine sand (Diam. 1-8—1-16 mm.)	A few miles.
Coarse dust (1-16—1-32 mm.)	200 miles.
Medium dust (1-32—1-64 mm.)	1,000 miles.
Fine dust (1-64 mm, and less)	Around the globe.

be wholly independent of the process of accumulation. It is now pretty generally conceded that the loess is genetically related to the Iowan drift,—perhaps the overwash from that sheet. It is also well known that the Iowan carried the largest and freshest bowlders of any sheet and it is reasonable to suppose that the finer materials were equally fresh at the time they were deposited. This is evidenced by the Iowan drift itself, the surface, only, showing any signs of weathering. The mud flats were, doubtless, much more important then than now, and if atmospheric circulation was equally as vigorous as at the present time, wind erosion and deposition would be much more widespread and important, and the rate of accumulation might be so much accelerated that oxidation and leaching of the rock meal would be imperfect or almost wholly wanting. The loess deposits, which have been protected by the Wisconsin drift, lend credence to this view. The exposures near Kelly and Ames are not only unoxidized and unleached, but still retain their original blue color, which is so characteristic of unaltered secondary deposits. These deposits also emphasize the extremely short time interval between the deposition of the loess and the Wisconsin advance. The loess, where unprotected, is a straw to gray-brown throughout, and the lime concretions sufficiently attest that incipient leaching has begun. In places where the deposit has neither lost by erosion nor gained by deposition, the leaching zone varies from two to four feet in thickness and is identical with the wind accumulations along the streams of to-day. The former, in all probability, originated through the rapid accumulation of perfectly fresh materials from the extensive mud flats and overwash plains, which formed an apron to the Iowan till sheet, while the latter represents the much slower assembling of the leached and oxidized materials from the alluvial plains of to-day.

While the processes which obtained during the two sets of deposits cannot be demonstrated to have been identical, their inherent resemblances and environments are certainly very striking. Aside from the comparisons already made, they are very closely related faunally. Professor Shimek* has shown, that with few unimportant exceptions, the loess molluscs were all air-breathers, whose habitat must have been very similar to that which prevails in the Iowa-Nebraska region of to-day.

*The exhaustive memoirs which embody the results of this keen, conscientious observer and conservative writer may be found in the recent volumes of these proceedings.

NEW LIGHT ON THE DRIFT IN SOUTH DAKOTA.

BY J. E. TODD.

Hitherto, the writer's study of the drift of South Dakota has led him to consider it to belong mainly, if not entirely, to the Wisconsin epoch. The reasons briefly stated are as follows:

(*a*) The numerous borings made in the state for artesian wells, have nowhere revealed distinctly, well defined forest-beds or soils, such as are found in some other regions. Though limited sheets of sand have been found in till at certain points, it has not been clearly proved that they are not such as might have been formed by sub-glacial streams or a slight advance of the ice-sheet during a single period of occupation. A few exposures described herein in the eastern part of the state have thrown some doubt upon this point.

(*b*) The drift in northeastern Nebraska, though suggesting previous advance by an ice-sheet, is, nevertheless, from its thinness and its relation to the Altamont moraine, thought to be due, in part, to the marginal waters; with a possible sub-glacial origin for a portion of it resulting from an extreme advance of the ice-sheet, slightly antedating that moraine. Because this conclusion seemed to disagree with those derived from other regions, the writer's results of several years' work in the Missouri valley have been withheld from publication for several years.

This summer, while revising these results, the following inference presented itself. It is strange that it had not suggested itself before.

I. *Inference from the Trough of the Missouri River.*—Since 1884, it has been generally recognized that the relation of the outer moraine and its drainage channels and attendant deposits, to the Missouri river, and the narrowness of the channel of the latter above Yankton, with the reflection of pre-glacial topography in the ice movements, all indicate that the Missouri river was displaced from the James river valley, and forced to take

its present course above Yankton, by the advent of the Wisconsin ice-sheet. Now the inference mentioned is this: that if the Missouri was so displaced by the Wisconsin advance (and this hypothesis certainly furnishes the best explanation of the known facts), then the James river valley was occupied by the stream previous to that time, at least during the so-called Kansan stage. (Possibly some of its upper tributaries may have discharged to the northeast in pre-glacial times.) If so, we can hardly conceive any sub-glacial till occurring in or west of the axis of that valley or in the Missouri valley above Sioux City. That the James river valley and that of the Missouri river below Yankton, are really identical is indicated by their widths and depths and relations to the drift. If this were not true, then we must believe that both the James valley and the wide Missouri valley below Yankton are of pre-glacial origin to their present depths; that the Missouri was displaced by the Kansan advance; that it must have had another channel below Niobrara or Yankton in that epoch, and that that channel has been so filled that it is unrecognizable, while the Missouri below the latter place has been kept unfilled in some inconceivable way during the recession of the Kansan ice and particularly during the deposition of the loess. If the latter be true, it adds another complication to the problem of the origin of the loess. If the James valley was not a pathway for ice during the Kansan stage, then, if the till in Kansas is really of the Kansan stage, the ice forming it advanced from the Des Moines valley, and the first excavation or the re-excavation of the trough of the lower Missouri is post-Kansan and post-loessial. This the writer urged in his Missouri report,* where he also pointed out an adequate cause for the subsequent great erosion, in the floods of water coming from the whole western margin of the retreating ice-sheet, as well as from the eastern slope of the Rocky Mountains; but he refrains from theorizing further till we have considered other recent observations. We shall find some difficulty with this view.

II. *Old Soil in the Big Sioux Valley.*—Early in September last the writer, with Mr. Bain, of the Iowa Geological Survey, and Mr. Leverett, of the U. S. Geological Survey, visited some instructive localities, near Sioux Falls, which had attracted the attention of the writer; first, in his examination of

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*Missouri Geological Report, Vol. X.

the region in 1884, and later, during the season of 1897. Allusion is made to former observations in Bulletin No. 1, of the South Dakota Geological Survey. In the grading of streets in Sioux Falls, at several points, a dark band resembling soil was noted. This is true more particularly north and west of the brewery. This band was first explained by the writer, as marking a temporary flood-plain of the Big Sioux during some stage of the occupation of the outer moraine He was unable to find evidence of its extending very far from the stream. The soil was underlain by till, and also overlain by that which seemed to be of nearly the same age. During the recent visit, not only were these localities re-examined, but others, developed by more recent grading, were observed near the postoffice, and a more notable example was found a mile or more northeast of the postoffice, in cuts along the Illinois Central railroad. At the latter point, there were found distinct traces of a buried pond, somewhat like a basin of the present. In its deeper portions, there is a depth of several feet of dark soil, containing numerous fresh-water shells — Valvata, Planorbis, Limnea, and also fragments of a cervical vertebra of a large vertebrate; fragments of turtle-shell, resembling the common mud-turtle in appearance and size, and two or three small bones, apparently of an animal about the size of a rabbit. The visit was brief, and further investigation would doubtless reveal more fossils. The vertebrate remains were submitted to Prof. William B. Scott, of Princeton, who determined the largest to be a cervical vertebra of a horse. The other bones were undeterminable.

Through the thoughtfulness of Mr. Bain, a series of the shells was submitted to Professor Shimek, in time to have his determinations for this paper. His report is as follows:

"The following are from the Illinois Central railroad cut east of Sioux Falls, S D.:

"1. *Planorbis bicarinatus* Say.

"2. *Planorbis parvus* Say.

"3. *Physa heterostropha* (Say) Say.

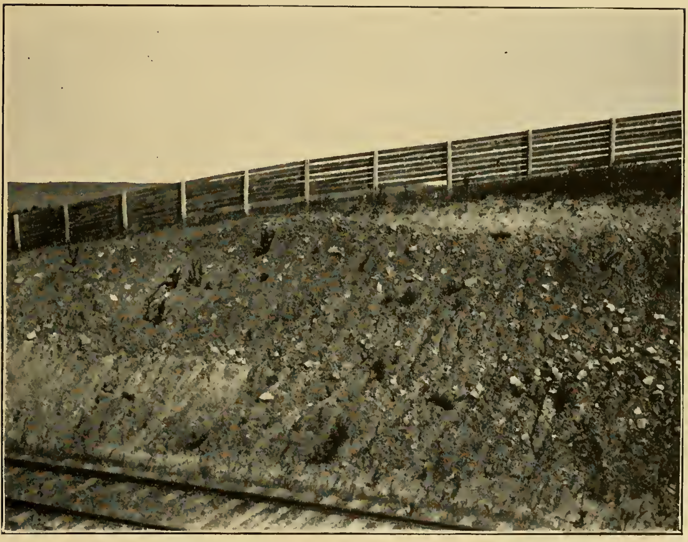
"4. *Limnea caperata* Say.

"5. *Valvata tricarinata* (Say) Say.

"6. *Sphaerium sulcatum* (Lam.) Prime.

"7. *Pisidium compressum* Prime.

"8. *Vallonia costata* (Müll.) Ster.



Buchanan Gravels East of Sioux Falls.

"Of these, one to four are *Pulmonates*, five is a gill-bearer (*Prosobranch*), six and seven are bivalves, and eight is terrestrial. The set one to seven can be duplicated in most of our northwestern ponds with muddy bottoms. Eight is terrestrial, but grows sometimes near the edges of ponds and is common along streams. There is one specimen of this.

"The other lot from Sioux Falls, S. D., 'near the brewery,' contains two species:

"*Limnea caperata* Say, and *Planorbis albus* Müll., probably. The specimens are poor. Both of these are common in northwestern ponds to-day."

West of this pond hole the rest of the underlying till had apparently had its soil, if ever formed, removed by the erosion attending the deposition of the overlying till. Between the two tills is a considerable deposit of gravel. The lower till was comparatively free from pebbles of any considerable size and has been referred to by the writer in his correspondence as a pebbleless clay, but more careful examination during the recent visit, brought out the fact that it contains small pebbles of crystalline rocks evidently of northern origin. In places it is distinctly weathered and resembles loess in color. In such cases, it failed to show effervescence when tested with acid. In the overlying gravel were numerous rotten pebbles and bowlders. The overlying till revealed few, if any, rotted bowlders. This break between the lower till and the upper till which is so distinctly marked at some points in the vicinity of Sioux Falls seems quite even and horizontal. In the city, tests with acid did not distinctly show difference in age between the upper and lower tills. In general, effervescence was prompt.

East of Canton, there was a similar difference noted between the upper till, which was quite stony, and the lower comparatively pebbleless till, which presented similar characteristics to those noted northeast of Sioux Falls. Between these tills was a deposit of fine sand and interstratified silt. Traces of this same horizon were traced east of Beloit, Iowa, and west of Fairview, S. D. In the latter locality, the lower till was not distinctly traced. It may be remembered that Mr. Bain, in his report on Woodbury county, Iowa, calls attention to the fine sand underneath the till at a high level northwest of Sioux City. At that point, no till had been found underneath the sand. It is known at one or two places to rest immediately upon Cretaceous beds. In that sand, which is excavated extensively for

use in Sioux City, there were found teeth, which were determined by Professor Cope to be *Equus major*. They would correspond in size, so far as can be judged, to the vertebra found near Sioux Falls, and it suggests in a striking way, that we may have here traces of the "Equus" or "Sheridan beds" that have been observed extensively in western Nebraska and Kansas. It perhaps should be added that quite thick deposits of till with gravel occur at a lower level near the Missouri at Riverside park, and seem to be of recent date.

III. *Observations Near Garretson.*—The same party also visited Garretson, northeast of Sioux Falls, not far from Palisades, S. D. That locality is especially interesting because of a small semi driftless area adjacent. Along the railroad the cuts from Palisade to about two miles north of Garretson, failed to show anything like till, and loess was exposed several feet in depth resting upon the surface of red quartzite. This red quartzite is cut into ravines at least forty feet deep in places, but there is no trace of any mass of till, nor of striæ on the surface of the quartzite. More careful examination showed that a few scattered pebbles and bowlders of northern origin were to be found in the crevices of the quartzite, but nothing that would demonstrate that the region had ever been mantled with a deposit of till such as occurs elsewhere. East of town within a few rods, the till appears and in gravel beds found in that direction numerous rotten granite pebbles were found indicating greater age than is common within the moraine. About a mile east, and further to the southeast and south, are conspicuous knolls, largely composed of drift gravel and sand, resembling osars. About a mile south of the town, one of these has been cut into and building sand has been taken from it for several years. It shows several feet of gravel and pebbles resting upon a mass of irregularly stratified sand. In a railroad cut to the east of it, there is found the unusual appearance of a stratum of gravel and bowlders overlain with loess several feet in depth, and resting upon a loess-like silt which is also shown several feet in thickness in some places, while elsewhere it is replaced by loose sand. It could not be distinctly shown that the lower silt was of markedly older age than the upper.

IV. *Preglacial Deposits in Turkey Ridge.*—In the examination of Turkey ridge, there was found, at a point about four miles south of Irene, Clay county, S. D., a stratum of loess like loam

underlying the drift, and resting, judging from an exposure of that several rods away, upon chalk deposits. A more careful examination may possibly reveal the characteristics of older till in these deposits, but no pebbles were noted where it was studied. Reports from wells in the region seem to corroborate the idea of a preglacial silt in that locality. Turkey ridge is a high divide between the Vermillion and James rivers, which became an interlobular portion of the Altamont moraine.

V. *Recent Fossils from Near Bradley, Clark County, S. D.* —In 1895 Miss Helen M. Buzzell, a teacher in the common schools, became interested in some curious things found in digging wells a few miles north of Bradley. I have not been able to visit the locality and can only quote from her description: "The land here is very rough, showing hills, little level places and big sloughs, or old lake beds The well is about fifty rods from the foot of a hill, which, I should think, is nearly 300 feet high, at the head of a slough. The latter is hardly a ravine—rather a hollow—and here are the figures as given by the man who dug the well, describing the different soils as they came:

		FEET.
1.	Black loam	3
2.	Crumbly yellow clay	14
3.	White material	3
4.	Tree	9
5.	Blue clay	6

"This is on Mr. J. D. Foley's place, section thirty-five, Spring Valley township, six miles from Bradley; there are others similar."

The white material is evidently a white marl. It contains *Valvata tricarinata*, *Planorbis bicarinatus*, *P. parvus* and *Limnea humilis*. Miss Buzzell sent numerous pieces of wood, most of which I judged to be coniferous. They show the characteristic tracheids and resemble tamarack. Specimens of muck, No. 4, contain fresh water shells similar to those in No. 3, and also *Anadonta* and *Spœrium bulcatum*. The data are not sufficient as it would seem for asserting that this deposit is interglacial. It may result from the filling of a recent lake basin. If such is the case, it resembles the locality north of Grand View, in Douglas county, which was described in Bulletin No. 1, of the South Dakota Survey, page, 126. Both localities are inside the Altamont moraine.

Conclusions and Suggestions.—From the data given, we seem justified in concluding that there had been considerable deposition of till over the region of the Big Sioux valley, previous to the occupation of the Altamont moraine of the Wisconsin epoch. The readiest explanation, no doubt, is that the ice sheet spread, at least, over the region mentioned, although it seems not impossible that the comparatively pebbleless till which has been observed at Sioux Falls and east of Canton, may have been deposited by marginal waters, and while occasional bowlders are found they are by no means as numerous nor as large as in the Wisconsin till. From the comparatively driftless region ab)ut Garretson and the direction of the striæ west of Palisades, we can scarcely doubt that the valley of the Big Sioux was occupied by a lobe of ice but that there were patches east which were comparatively stationary,

We have not given the subject sufficient study to speak with confidence and yet it seems permissible, at least, to offer a few suggestions which are little more than speculations.

If we examine the map of the region, we shall find that the valley of the James river in South Dakota is separated by a high table land rising over considerable of its surface, to a height of 2,000 feet above the sea. Immediately north of the South Dakota line, the James river makes its nearest approach to the Red River of the North, the distance being about seventy miles. At that point the divide between the streams is very low and close to the former stream. A cut of twenty to twenty-five feet would probably turn the James river into the Wild Rice and Red rivers. From that point northward, although the divide is about 150 feet above the James, there is no we l defined ridge, as further south. This brii gs us to a serious objection to the view that the course of the Missouri was down the James river valley, especially while the mass of ice was moving up the Red river valley. Moreover, some have thought that the ancient drainage was once northeast through the valley of the Wild Rice. If such were the case, the difficulties of keeping the James river valley open for passage of the water while the Red river valley was occupied by ice, would be still more difficult to explain, if not inconceivable. It seems, therefore, more probable that the dividing ridge, which is now so well defined in South Dakota, previous to the Wisconsin epoch, extended further north, possibly as far north as Devil's Lake; though it was narrower and probably lower there than

farther south; and that this ridge played an important part in hindering the advance of the ice until it had accumulated sufficiently to break through into the James river valley, as it did during the Wisconsin epoch. This would be the more easily explained if the ice sheet from the north, *i. e.*, from the Keewatin center was not so vigorous in the early stages, *i. e.*, in the Kansan and pre-Kansan stages.

From a general consideration of the extent of the so-called Kansan till as compared with the Wisconsin, we may infer that the natural center during the former stage was further east; probably, northeast of Lake Superior. In fact, we may conceive that some of the higher points north of Lake Huron were the first to receive a permanent ice cap. As the region became more chilled, the zone of accumulation would extend naturally along the more elevated surface of the ice and then the greatest accumulation would lie naturally near the edge of the zone and advance slowly outward. In this way, we may perhaps account for the greater vigor of the streams passing down Lake Michigan and Lake Superior during the Kansan stage or, as some would say, the latter during the Kansan stage and the former during the Illinoian stage. If we believe the ice to have here pushed forward southwest in the axis of Lake Superior basin, it is not difficult to conceive that its course would lie diagonally across the state of Minnesota, being confined in a broad shallow channel between the highlands about Itasca and the region of central Wisconsin, that it was directed to the Minnesota valley and across it against the high transverse ridge of the "East Coteau" the high divide separating the Minnesota from the James, which now has an elevation of 1,700 to 2,000 feet. From the shape of the land and the course of the stream, it seems not unlikely that the highest elevations were along the axis of this stream. As the Des Moines valley to the south offered an easier slope, we may conceive the ice sheet to have expanded more rapidly in that direction and to have spread out during the Kansan stage, from that valley westward and south into northwestern Missouri. We may account for its failure to press westward over into the James valley by the elevation of the Coteau region and by the diverting influence of the Big Sioux valley, which we may suppose had greater effect upon the thinner edge of the ice which there lay in the zone of ablation.

The failure of the ice to press equally northward may be

accounted for, not only by the ridge, as we have before stated, but by the depth of the Red river valley together with the delaying influence of a north slope. For we conceive it reasonable to suppose that the ice would be more plastic in the region of greater warmth and that there would be more rapid accumulation along the southern side of the zone of accumulation. Both relations would favor such a conclusion.* If such a state of affairs is conceivable, we may not only account for the Kansan till, so far as it is sub-glacial, but we may have found a partial explanation of the more difficult phenomena of the course of the ice during the Iowan stage. One of the strange things connected with that stage is the persistent course of the ice toward the southeast. Now, if the summit of the ice lobe, during the Kansan stage, rose to the altitude of the zone of accumulation in western Minnesota, we may conceive that it might for a time act as a secondary center of glacial motion. The persistent easterly tendency of the ice might be partially accounted for in this way, but we may find another factor in the possible subsistence of the driftless area. The very existence of that area has suggested its former greater elevation, and we have learned to expect subsidence as one of the effects of ice occupation. The Kansan load, acting for a time on the west, and subsequently, if not in part contemporaneously, the Illinoian on the east and south may have at last brought it down to a considerable lower level. The movement of the Iowan ice lobes, both in Iowa and Illinois, would harmonize with such a view. See Leverett's map, "Interglacial Deposits in Iowa," page 8.

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*Moreover, Mr. Upham's study of Lake Agassiz would lead us to think there was then greater northward elevation.

SOME PHYSICAL ASPECTS OF GENERAL GEOLOGICAL CORRELATION.

BY CHARLES R. KEYES.

CONTENTS.

INTRODUCTORY.

The main object of the present communication is to formulate, briefly, certain results which have been obtained in the course of recent attempts to parallel some of the geological terranes in the Mississippi valley. The suggestions they offer appear to have a much more than local bearing, and to affect the stratigraphy of the entire region. They also have an important influence upon the whole problem of general correlation and, perhaps, also, even upon our present system of geological classification.

In the whole domain of natural science, there is perhaps nothing that is more striking, through all stages of its consideration, from beginning to end, than the fact that natural phenomena are rarely the outcome of the action of single, simple laws. They all originate in so many remote and complex processes that those which are really primary and essential in character, are often largely or completely obscured by those which, though most conspicuous perhaps, are altogether

secondary, or even accidentally associated. That this is true in every department of science is clearly shown, not only by its history, but particularly by the classifications of the phenomena that have been followed during the different stages of its development.

In the progress of every branch of knowledge, one of the first considerations to receive attention is a systematization of the known facts. This orderly arrangement is one of the earliest prerequisites demanded of the branch in its attainment to recognition; while its advancement is measured by the degree of taxonomic completeness and the critical criteria adopted. The bringing together of the various phenomena, so that some sort of systematic relationship is made to exist among them all, is the initial step in raising the particular department of knowledge to the dignity of a science. As progress is made, a gradual evolution takes place in the fundamental grouping of the facts. In the beginning, a classification, rude though it may be, is fashioned according to the superficial features, which are most striking at first glance. It is, at a later stage, modified to one in which similarity of characters, irrespective of natural relations, is taken into account. A vastly more advanced conception is classification based upon affinity, in which, for similarity of features, there is substituted similarity of plan. The final stage is the causal, in which origin and the processes become the dominant and determining factors.

In the expansion of the multifaceted science of geology, the classification of the phenomena presented has been no exception to the rule. In the department of stratigraphy, that part of the general subject which has to do with the history of the changes which have taken place in the lithosphere, that part in which we find a measure of geological time, and in which we determine the sequence of geological events, there has been the same growth as in the other branches of the science. As in those other branches various standards of comparison have given away, one after another, to new standards more in accord with the general advancement of human knowledge, so also in stratigraphy has there been a passage from one criterion to another. In the successive replacements, however, of one set of criteria by another, the abandoned ones have not always been found to be altogether wrong; and they usually continue to exert a more or less profound influence long after they are thought to be forgotten. These various classifications, based

first upon some one particular phase or striking feature, and then on another, are not entirely erroneous, for the reason that they represent some special workings of fundamental laws that are not, and cannot be, always discerned, until greater advancement in general knowledge has been made. In this respect, they partake of the nature of working hypotheses. A long time may be required to prove their faults, and then new schemes arise. In practice, then, the establishment of a rational system of geological chronology, or classification, is not to be sought in the comparison of any one set of external features, but rather in the direct causes or processes which have given rise to the phenomena. The final outcome is reached by a comparison of all the groups of data relating to the physical history as a whole.

NATURE OF THE PROBLEM OF GEOLOGICAL CORRELATION.

Regarding as the main function of geological correlation, the establishment of a practical scale of stratigraphic succession, to which may be referred all geological terranes, the critical critera adopted become essentially the basis of geological classification or of historical geology. Moreover, a rational classification of geological phenomena reflects the genesis of the events recorded, and this is manifestly the ultimate aim of all methods of paralleling strata.

It is a favorite simile of geologists to liken the progress of geological events to human history. But they stop short of the most important step of all in not making the comparison full and symmetrical. In the history of mankind, there is in the time units, the year, the decade and the century, an absolute scale for gauging all events. In developing geological history, this standard of comparison, of course, fails, because of the inapplicability of our ordinary units of time, and with this failure, no attempt is made to carry out the all-important idea that is fundamental in human history, and look for some other unit that is, in its nature not comparative, not variable, not local in application, but fixed and independent of any inherent character.

As human history is traced backward, the clear coloration of the present gradually fades with time, until lost in the haze of distance and uncertainty, tradition and myth. That the growth and progress of the races of mankind have been much the same in all the various parts of the world, is generally

admitted, but in each part the details, and perhaps some of the characteristic larger features, are very different. The whole history is made up of the histories of the parts, of the nations, of the provinces. In a similar way, geological history reaches back into a haze of distance, compared with which the beginnings of human history are but as a moment ago. As the history of man is a history of nations and dynasties, more or less intricately related, so also is geological history a history of parts, of provinces, overlapped, interwoven, merged into one another, but each retaining, more or less distinctly, its identity, thrusting out its idiosyncrasies, and presenting the evidence of its relations with its neighbors.

The development of geological provinces has another parallel in the progress of nations. Some great events have been recorded in the history of all; others in only a few. At certain periods a mingling, an absorption, or a complete effacement of some parts has taken place; at other times has occurred conquest and expansion.

Could the events of all nations that have ever existed be arranged on a chart, or in tabular form, so that those concerning each could be brought together in a vertical column, and so that the different columns would stand side by side in their proper positions in the time scale, with its major subdivisions marked off by horizontal lines, it would be found that at certain times great events would affect several and perhaps many nations, and that at such times similar events would affect different groups of nations, or part of one group and part of another.

In the same manner are the events of geology recorded in different parts of the earth. While the general sequence is similar everywhere perhaps, great changes affect the different parts in different ways and with varying intensity. So, in tab ulating the geological events of different provinces, the standard corresponding to the time scale in human history must be absolute and far-reaching, and not changeable and local. The determination of such a standard is the one great problem of stratigraphy.

THE FOUNDATION OF GEOLOGIC CORRELATION.

In the correlation or comparison of geological terranes, experience has shown that the subject may be viewed from at least four very different points of vantage. The aspect

presented may be: (1) Local, (2) provincial, (3) regional and (4) general. The last should be clearly distinguished from the others. With the various methods which have been followed from time to time in correlative inquiry, the almost universal practice has been to attempt to base the broader generalizations upon criteria that are, in reality, applicable only to limited areas. Hence, in passing from the more local to the more general, difficulties have always arisen which have become more and more formidable in direct proportion to the extension of the local scheme. Most of the methods that have been applied, and that have been found to answer locally, have fai ed when extended over larger districts. The real problem, then is to find some means of solving the difficulties of the latter, or more general. In the attempts to do this, or when broadly applied, most of the correlation criteria have proved very inadequate. A little consideration will make the reasons evident. As the specific distinctions that are regarded as decisive in a given locality are extended more and more widely, they change and all are gradually replaced by others which may be very different. The physical conditions that have given rise to the various distinctive features, or the processes involved in their production, themselves change from place to place and from time to time. In seeking for a suitable means of carrying on correlation it is manifest, at the outset, that in no case should the critical criteria deal with the intrinsic features as such, but with the causes producing them. Moreover, the great factor to be taken into account in every standard of comparison which has to do with the correlation of strata, is a definite or absolute basis to which the various minor, or local and provincial, successions can be referred. This fundamental conception grows out of a consideration of the nature of sedimentation itself.

The features which have in the past had the greatest weight in geological correlation, have been those which, in reality, are partly or entirely unrelated to the deposition of strata. In attempting to seek a criterion that is fundamental in stratigraphy, it is pertinent at the start to inquire into the real nature of sedimentation, into the causes producing it, modifying it and limiting it, into the forces called into action, in subsequently obliterating their results, in fact, into all of the primary processes involved, and into the secondary processes which tend to obscure the actual workings of the real and

fundamental laws. Only in this way can the main object, the establishment of an adequate and elastic system of geological correlation, be attained, and a ready interpretation of the history of terrestrial phenomena be made. Since, from the strata of the globe must be deciphered the records of its history, the leading facts to be ever borne in mind and to be recognized to their fullest possible extent, are that the elements of sedimentation are in large part the products of land decay, which form seaward-creeping fringes around the continental masses, and that the cessation of the action of the processes favorable is one of the prime factors in beginning each new cycle, or great epoch, in the physical history.

SOME METHODS OF GEOLOGICAL CORRELATION.

General Statement.—In the present connection it is unnecessary to enter into details regarding all of the various standards of correlation that have been proposed. As all systematic arrangements of sedimentary deposits have for an ultimate end the real determination of the superposition or relative succession of all strata, it is manifest, from what has already been said, that the scheme incorporating in its plan the actual sequence of the processes that have produced the events, is the one which most nearly meets the requirements of a rational foundation for geological chronology. In proportion, therefore, as a classification is genetic, it is of value as epitomizing the history of a region.

From the time when the real significance of the bedded character of nearly every portion of the lithosphere open to observation first came to be recognized, at the beginning of the eighteenth century, the normal order of superposition and the equivalency of the layers has formed one of the chief problems of stratigraphy. In a single rock exposure it is, ordinarily, easy to determine which beds were laid down first and which last. However, in making a comparison of two sections which are not visibly connected, the case is not so simple; and when the two sections are widely separated, the difficulty of paralleling them is correspondingly increased, and exact correlation, perhaps, finally becomes entirely out of the question. It is the special province of geological correlation to establish a general chronological sequence of all rock successions, particularly those more or less widely separated. In the past, the standards for this determination have been

numerous. As they come to be tested practically in the field they have been, one by one, abandoned entirely, passed over, or, in lieu of something better, have been used only provisionally, or with reservation. No single criterion has yet been proposed that answers the purpose successfully. Although some one of the various methods is commonly used as the principal one, others are almost invariably also taken into account at the same time. Hence, it is universally recognized that few correlation problems can be now settled by a single standard alone.

Chief Methods.—In geological correlation the most important of the criteria that have been most generally employed may all be assigned to two main groups, the biological or biotic, and the physical. At one time or another, each one of the subordinate methods of both groups has been made all-decisive. At the present time all of these are used to some extent, either directly or indirectly. These minor methods have been recently arranged by Gilbert* in the following manner:

I. Physical, through,

1. Visible continuity.
2. Lithological similarity.
3. Similarity of lithological sequence.
4. Unconformities.
5. Simultaneous relations of diverse deposits to some physical event.
6. Comparison of changes deposits have experienced from the action of geological processes supposed to be continuous.

II. Biotic, through,

7. Relative abundance of identical species.
8. Relative abundance of allied or representative species.
9. Comparisons of faunas with present life.
10. Relations of faunas to climatic episodes.

With possibly one exception all the methods of correlation which are included in these two catagories are strictly local in their scope, though it is the custom to regard them as applying widely, if not universally. For many years general correlations have been carried on almost entirely by the biotic methods. At the present time they predominate over all others,

*Cong. gèol. international, Compte Rendu, 5me Sess., 1891, pp. 151-155, 1893.

and are, really, the foundation of our commonly accepted system of geological synchrony. However, it is beginning to be recognized more and more clearly that organic remains are not the all-deciding factors in questions of correlation, that they are, in fact, merely accidental characters, and that when depended upon they must always be taken in connection with physical features. In actual practice they are regarded as corroborative evidence after the main points of the special problem under consideration have been determined by other means.

In the recognition of these difficulties it was recently stated* that all the principal characters, stratigraphical, lithological and faunal, of every formation, were so intimately interrelated in origin that the proper interpretation of any one of the three classes of phenomena presented should, under normal conditions, indicate the more salient features of the other two, but that, ordinarily, great difficulties were encountered in attempting to infer the entire geological history of a series of beds from a single group of facts. It was fully appreciated that the geological records were very imperfect, but at the same time they were not believed to be nearly so fragmentary as generally supposed, though the larger part was, in a great measure, more or less inaccessible; those portions of the lithosphere that were open to investigation were as yet only partially considered. For a long time to come, the territory open to inspection would require constant study before the history could be made even measurably complete. Nevertheless, at the present time, it was considered absolutely necessary to carry on investigations, involving the historical sequence of geological events, along all three lines at once, every fact being needed to throw light upon the general scheme. If the problems were attacked in any one of the three directions alone, without due regard for the evidence presented by the others, very different, and perhaps antagonistic, conclusions might be reached, at least in the present state of knowledge. In the interpretation, then, of the geological history of a region, and in the erection of a classification of the formations in accordance with that interpretation, it is of prime importance to weigh carefully all the evidence set forth by the arrangement, composition and contained organic remains of the rock series as a whole, and of its several parts regarded as distinct units.

*Iowa Geol. Surv., Vol II, p. 62, 1893.

Inadequacy of Existing Methods.—It has already been intimated that the basis of geological classification has been, at various times, in accordance with very different standards, and that these have continually changed. In passing from one to another, however, the change has been gradual and not abrupt. Being bound so inseparably to the past, it is well-nigh impossible for us to at once cast aside old ideas, even after we are fully convinced of their untrustworthiness. So, in clothing new conceptions in words, we unconsciously and unavoidably incorporate statements that are not only deceptive, but which have their foundation in error. Still, the expression of the new must be largely in terms of the old. In the discussion of our standards of comparison, the old interpretations are naturally, yet unavoidably rendered, and more or less misunderstanding necessarily arises at first in the consideration of any new criterion.

That every standard yet suggested for the determination of geological chronology has beeen inadequate, when taken singly, is conclusively shown by the practical tests that are being continually made. A satisfactory solution to the problem does not appear to be offered by any system yet proposed. It has almost come to be the despair of investigators.

A few years ago, Whitney and Wadsworth* gave up all hope of unraveling pre-Cambrian geology without the use of fossils.

Walcott,† after reviewing the methods of correlation in his correlation essay on the Cambrian, concludes that "For the determination of synchrony, except in a limited area, there is little hope for satisfactory conclusions by any method yet devised."

Gilbert‡ states that at present "the legitimate use of physical methods of correlation will necessarily be local * * * The value of a biotic group for purposes of correlation depends (1) on the range of its species in time and space, and (2) on the extent to which its representatives are preserved."

Hughes,§ in presenting the report of the British subcommittee on geological classification, clearly recognizes the fact that no one criterion is sufficient. "We must adopt the historical method * * * In geological history we must class together those results which naturally hang together, which

*Bull. Mus. Comp. Zool., vol. VII, p. 565, 1884.

†U. S. Geol. Sur., Bull. 81, p. 433, 1891.

‡Cong. gèol. international. Compte Rendu, 5me Sess., 1891, p. 153, 1893.

§Cong. gèol. international, Compte Rendu, 4me Sess., 1888, App. B., p. 9, 1891.

belong, more or less, to one set of conditions as shown by the similarity of the inhabitants, as well as of the country occupied, and of the structures which remain; that is of the fossils, the stratigraphy and petrology of the district. Our greater divisions must be based on the more complete changes and the smaller upon the minor fluctuations which will be indicated only by the more sensitive and specially adapted forms of life, or by the more minute structural changes."

EXTENSION OF THE USUAL CRITERIA TO GENERAL APPLICATION.

Main Considerations.—Among the various methods of paralleling strata, and in the broader phases of their consideration, there are certain points in several of them to which attention should be directed. The methods referred to are those which have, of late, received the greatest consideration. They may be included under the titles of (1) biological relationships, (2) unconformity, (3) community of genesis, (4) historical similarity, and (5) physiographic development.

Biological Relationships.—As the various standards that have been usually used in geological correlation have been finally found to be useful only in limited areas, instead of being world-wide, or even of continental application, so also the latest one, which has so long held prestige, has been found at last to have no longer the unerring certainty in exact correlation that was once claimed for it, and in this respect to be no longer keeping pace with the advance of geological science. Like the other methods or schemes, it too is having its usefulness restricted to limited districts, and to be relegated to the subordinate position of a local criterion. Its accuracy remained unquestioned in the absence of more reliable criteria with which to check its results. With, however, the advent of more refined methods of working, its unreliability in exact general correlation has become very manifest. As a striking example, stands the eastern sea-board of the United States. Of it, McGee says that "nearly as much information concerning the geological history of the Atlantic slope, has been obtained from the topographic configuration of the region within two years as was gathered from the sediments of the coastal plain and their contained fossils in two generations."

It has come to be widely recognized that there are no more grounds for the claim that the succession of organic forms and faunas is an expression of the geological course of events and

that it is the same the world over, than are the claims of the old Wernerian ideas of general sequence, based upon lithological similarity. The element of error is identical in both. It is an assumed premise. Both the lithological and faunal characters must be regarded as largely accidental attributes of strata, and therefore cannot have the impeccable classifacatory values once ascribed to them.

The formulation of the weakness of fossil criteria in general correlation may be passed over here. They are fully noted in the conclusions of Huxley, Irving, Van Hise, McGee, Walcott, Brooks and others. The very basis of the method is highly variable, in the same way as that of lithological character.

The preëminent position which paleontology has long held in geology, has been in great part due to its biological relations, or environment. It has formed one of two chief lines of inquiry into one of the most important and most absorbing philosophical questions of the century. So overpowering has been its influence in stratigraphy, that it even has been urged that there can be no scheme of geological chronology which is not based upon it. As a science, paleontology had its rise in geology, though it is really a department of biology, and the vast expansion that it has undergone still closer welds it to the latter science. The whole tendency of its development, of late years, has been towards the biological side. Its use, in strictly geological work, has become more and more restricted and overshadowed by the physical sciences which offer a broader foundation. Without the slightest disparagement to its good offices in the past, it may be said that it can never have the exalted place in geology that it once had, though it will ever be of use in practical local stratigraphy, especially when taken in connection with other data

Another reason why paleontology long had such an unprecedented influence upon geology is that it was so thoroughly permeated with pre-Darwinian ideas of repeated creations and of sudden extinction of species and faunas. Hence no correlations, either local or over broad areas, have ever been precise, apparently, nor, in the absence of facts to the contrary. has the equivalencies of strata widely separated geographically been determined so positively, as those made out a generation or two ago. Even to-day geological correlations rest practically unchanged on these manifestly insecure foundations.

Since the beginning of the present century, when William

Smith* explained a method whereby the different strata could be recognized by the fossils which they contained, organic remains have been the foundation of all geological classifications. Of late years, when other methods have been devised, numerous discrepancies have arisen between the conclusions to be deduced from two sets of facts, and the question has begun to arise on all sides as to just how far the fossils can be relied upon in the correlation of geological formations. Huxley,† recognizing the fact that exact synchrony could not be established by means of fossils, proposed the term, homotaxis, indicating similarity and not time-equivalency of organic contents. Irving,‡ and later Van Hise,§ and others, working in very ancient, non-fossiliferous rocks were obliged to swing loose altogether from the use of organic remains. McGee,‖ in discussing the subject, concludes that, in correlating by means of fossils, ' it is the weakness of the method that many rocks are too poor in fossils to be correlated thereby; that formations may be homotaxial yet not contemporaneous, and *vice versa*; that fossil facies represent the product of two principal factors, of which one (environment) is so variable under local conditions, that the product is inconstant among the minor rock divisions, and that the geologic chronometers afforded by fossil plants, fossil invertebrates, and fossil vertebrates, respectively, give unlike time units and, sometimes discordant readings. To-day the larger groups are confidently correlated by paleontology; but leading American geologists no longer accept identity of fossil facies as final proof of equivalence among the minor rock divisions."

In his correlation essay on the "Cambrian of North America," Walcott¶ not only says, as already stated, that "for the determination of synchrony, except in a limited area, there is little hope for satisfactory conclusions by any methods yet devised," but in referring to paleontology in particular, remarks that "all paleontologic reasoning is based upon known data. By the discovery of a new grouping of fossils, or a different range of known species, the identification of horizons may be materially modified." As coming from the

*Geol. Table British Org. Foss., 1815.
†Quart. Jour. Geol. Soc. London, Vol. XVIII, p. 14, 1862.
‡U. S. Geol. Sur., 7th Ann. Rept., pp. 365-454, 1888.
§U. S. Geol. Sur., Bull. 86, pp. 511-524, 1892.
‖Am. Jour. Sci., (3), Vol. XL, p. 36, 1890.
¶U. S. Geol. Surv., Bull. 81, p. 422, 1891.

chief of American paleontologists, the recent utterances of H. S. Williams* are full of meaning: "And now the modern school of paleontologists are demonstrating the fact that the divisional lines of the biologic or time scale do not correspond to those of the stratigraphic scale, but are determined by independent factors." So diverse are the divisions suggested by the fossils in the time scale from those indicated by the stratigraphy in the formation scale, that the same author saw the necessity of a dual nomenclature;† of a distinct set of names for the members of the two scales.

In this connection, also there may be mentioned a discussion on the character of fossil evidence, by Brooks‡. It is especially noteworthy as coming from a biologist, and is from a standpoint that is not and cannot well be considered by the average paleontologist. Although it is not mentioned in the discussion, it may be inferred that the proof is conclusive that the fossils do not indicate the great antiquity of life that they are generally thought to, as deduced from the chief argument: that at the time of the earliest Cambrian forms life was already fully nine-tenths differentiated. It is shown that differentiation of life goes on with great rapidity along the shore, and more or less independently in different localities, on account of the fierce struggle for existence. The suggestiveness of the statement is startling; at a single stroke it practically deprives the fossils of the greater part of their value as trustworthy elements for general correlation, and relegates the whole method to the same rank as correlation by lithology, or similar succession The recent trend of paleontological progress has been rapidly in the direction of biology, rather than towards geology, but the effect of Brooks' suggestion is to remove it almost entirely from the latter field and to transfer it to the former. As in the case of certain of the other criteria of geological correlation, the usage of fossils becomes largely local.

The weakest point of all in general correlation by means of fossils is the great complexity of the problem surrounding distribution of organisms in space. The intricacy of the laws governing the geographic range of animals and plants, at the present time, is only understood in the most general way and

*U. S. Geol. Sur., Bull. 80, p. 267, 1891.
†Journal Geology, Vol. II, pp. 145-160, 1894.
‡Journal Geology, Vol. II, pp, 455-479, 1894.

scarcely yet capable of unraveling. How infinitely greater are the difficulties when not only space is to be considered but distribution in time as well, and all with material that at best is but fragmentary. No biologist would have attempted it.

Unconformity.—In its widest sense an unconformity is any discordance in sedimentation in which younger beds reposing upon older rocks give evidence of no direct connection, of interrupted deposition, or of a change in the prevailing physical conditions whereby nonparallelism is developed in the stratification planes of the two formations. The phenomenon carries with it the idea of more or less pronounced warping of the older strata before the younger are laid down. In a somewhat narrower sense, and in the one that it is perhaps most generally used, unconformity implies a tilting of the strata, their elevation above sea-level, and subjection to more or less profound erosion before being covered by the younger sediments.

The irregularity in the juncture between two uncomformable formations is, in the majority of cases, a well defined line denoting a break in the continuity of conditions. In Europe, where modern stratigraphical science originated, the time-gaps indicated by unconformities have been regarded chiefly from a biological rather than a physical standpoint. The full significance of the interruption in sedimentation has not been appreciated so much in its bearing upon the conditions which could have given rise to such effects, as in its production of a well-marked hiatus in the faunal successions, or rather, by the introduction of entirely new faunas, perhaps, in the younger beds above. In the European countries also, the abrupt faunal breaks have been at the foundation of the separation of geological history into its grander divisions, and of the strata into systems. In America the attempt to transfer the classification of Europe has not proved so successful, and the application of the same principles does not find the great gaps in the same places. The inferences are obvious.

As a purely physical feature, application of unconformity to anything smaller than the great systems, has usually been subordinated to the faunal or lithological criteria. It has been done, however, in a few cases with success; though not in such a way as to attract very much attention.

Although marked physical breaks in the continuity of sedimentation have, from time to time, received some attention in

problems of correlation, it remained for Irving* to point out its great value in the classification of the nonfossiliferous, pre-Cambrian rocks of the Lake Superior region. The practical use of this criterion in stratigraphy was also later invoked in the consideration of the Carboniferous of the Mississippi valley †

The special stress laid by Irving on the value of unconformities as a basis for geological classification, has a wide bearing. In the application of the principle to the region that was under consideration, it was shown that unconformities were the most important of all criteria in resolving into its grander subdivisions, a vast sequence of crystalline rocks, which, as in the case of other similar masses, had defied all attempts of satisfactory arrangement and correlation. Had Irving not been so untimely called from his field of labor, he might have possibly expanded his theme so that it would be of much wider, if not of universal application. It is not that he was the first to suggest the use of unconformities in delimiting the grander geological formations, for this, at the present time, is essentially the real foundation of our accepted geological classification. Other criteria, however, have so overshadowed this one, that the fact of its ever having assumed an important role is well-nigh lost sight of, and consequently the physical breaks in stratigraphical succession excite little attention, except as interpreted by fossils. Their true significance is now very nearly, if not completely, overlooked.

In the absence of fossils, Irving was actually driven to the use of purely physical methods in dealing with the metamorphosed rocks. All attempts to arrange the latter systematically, except upon faunal grounds, had been given up as useless. In other regions, many writers before him had considered the phenomenon of marked discordant sedimentation as a structural feature, and had actually gone so far as to regard unconformities as not only of regional, but even of intercontinental, extent. On the other hand, there were a very large number who believed that unconformities, at best, were only local phenomena and, therefore, of small importance in stratigraphy. It was Irving's particular mission to determine how far unconformities could be relied upon, in a limited district, to point out clearly that in some cases they

*U. S. Geol. Sur., Seventh Ann. Rep., pp. 437-439, 1888.

†Bull. Geol. Soc. American, Vol. III, pp. 283-300, 1892; and Iowa Geol. Sur., Vol. II, p. 29, 1894.

were of very wide, and in other cases of very limited extent, and, in the geological classification of the non-fossiliferous rocks of a whole province, to propose a plan in which unconformities occupied a prominent place Short though the period has been, since Irving's time, there has sprung into existence a new department of geological inquiry, that not only reads later geological history in the geographical forms presented, but gives an entirely new insight into the real significance of uncomformable relations between the older rock masses. The bringing in of the geographic aids, to unravel stratigraphy, finds a hearty support and a wide expression. It is in the extension of Irving's theme, as outlined under the guidance of modern geographic interpretation, that stratigraphy is believed to have found a rational and practical method of correlation and classification that, in its fundamental concepts, is entirely independent of the usual and almost universal paleontologic standard. The specific applications are referred to in another place.

Community of Genesis.—Correlation by community of genesis is a "simple application of the well known principles (1), that geologic processes may be inferred from their products, and (2), that geologic processes are universally inter-related." It is a method that was elaborated by McGee* for the more recent deposits of the coastal plain of eastern United States. In its more mature statement,† correlation by this principle "becomes a juxtaposition of episodes or is a correlation by historical similarity."

"The application of this mode of correlation involves such astudy of agencies and conditions of geologic action as to enable the geologist to determine provisionally the origin of each phenomenon examined, whether deposit or topographic feature, formation or land form; and the subsequent comparisons involved in the correlation are comparisons of genetic records, which may be made in such manner as to eliminate the incongruous and preserve the congruous, and thereby develop a consistent history for the entire province under examination. This method has already been characterized as homogenic, *i. e.*, correlation by homogeny, or identification by origin.

"In the practical app'ication of the method, the deposits of given sections and circumscribed areas are first correlated empirically by visible continuity and lithologic similarity, and to some extent by similarity of sequence, in order that their relations may be generalized; next, the agencies of genesis are inferred from the materials of the deposits viewed individually and collectively; then the unconformities and pebble-beds,

* Am Jour. Sci., (3), Vol. XL, p. 36, 1890.

† Cong gèol. international, 5me Sess., p. 164, 1893.

with other aberrant phenomena, are generalized, and from them, in connection with the normal deposits, the conditions of genesis (*i. e*, the attitude of land, proximity of rivery, etc.) are inferred. By these means a tangible and definite picture of the topography, geography and geologic agencies of the area is produced; and the various inferred features are tested by their consistency and the inconsistent eliminated or withheld for more extended comparison. Then the history of the contiguous area is wrought out in similar fashion and the episodes are compared severally and jointly, and the deposits and unconformities are interpreted in the light of this comparison. The comparison is eventually extended to other portions of the province and to the contiguous provinces, and in each area the significance of the sum of phenomena is sought and the inferred histories are generalized by combination of the congruous and elimination of the incongruous until finally the history of a given period throughout the entire province is interpreted in terms of episodes each inferred from the sum of phenomena representing the period."

As originally suggested correlation by homogeny had long been in general use, in one phase or another, but the method had lacked definite formulation. Its main distinctive features were in emphasizing the importance of the recognition of a commitant period of land degradation, with each period of deposition and in the inference of the agencies from the materials of deposition. As set forth in its latest form, the theory has been so expanded that its very name loses its significance and becomes a misnomer. Instead of designating a method of correlation it is a synonym of geological history itself. Its foundation is entirely new from what it was in the beginning and its distinctions are taken almost out of the realm of observational science and are placed in the metaphysical.

In its most acceptable form, it is a special case of a more general proposition, in which refinement of determination is carried out far beyond a point where the method can be of general utility in geological work. With the older formations its use will be very limited. It is better adapted to the latest deposits, but even among these its office will be necessarily restricted, for with its practical use there is postulated comparatively little effacement of the geological record of the region. Moreover, it is a method that is local in application and not general. As in the cases of lithological similarity, the biotic, and most other methods that have been commonly used, it makes no provision for correlation of provinces the geological histories of which have been not similar, but dissimilar.

Historical Similarity.—Practically, this method has been in use for a long time, though not always clearly emphasized.

It begins to show itself in the adoption of more than one method of correlation. In its latest significance, the term has come to cover the united conclusions derived from all methods of correlation. At first glance the method has much merit; but further consideration brings out the same fatal defects, in its application to general problems, that are apparent in the older and more widely used methods. It is essentially local in its extension, and hence is on the same plane as the individual methods it brings together. It fails to parallel the strata of provinces of different geological origin.

Physiographic Development.—The modern physiographic principles, as enumerated by Davis,* Gilbert † and others, have an important bearing upon geological correlation. Their direct application, however, is confined to only the later formations. Their chief value lies in the suggestions they have made regarding the real basis of geological classifications and correlations, and in showing conclusively that a general consideration of the problems is not to be sought in any one of the criteria yet set forth. The fundamental principle that is of such prime importance to stratigraphical geology is that with each marked uprising of the land surface there are produced phenomena which are as ineffaceably impressed upon the portion of the earth's crust above the sea, as is deposition itself below the water level. The final reduction, through erosion of the elevated land surface, to a more or less even plain lying but little above the sea, the formation of a peneplain, is a phase in the geological development of the region, the full force of which has been until recently entirely overlooked. When the lowland plain is depressed below tide level and covered by sediments, unconformable relations of the two formations are produced, but the line of unconformity, instead of indicating merely an hiatus, or blank gap, devoid of interest, represents a chapter in the history of the region that is even more pregnant of eventful happenings than those recorded by the contiguous formations that were formed during the same period. The time-gap, and not the formations, are, therefore, the all-important features in marking off the ages, epochs and periods of geological history. The latter stand for continuity of record; the former for interruptions which render a classification possible.

* Nat. Geog. Mag., Vol. I, pp. 183-253, 1889.

† U. S. Geol. Sur., Mon. I, pp. 393-402, 1890.

Correlation by comparison of the stages of physiographic development is highly important, and fertile of exact results in the later deposits, but it cannot be extended directly to the older formations, though the principle is of first importance.

CORRELATION OF PROVINCES OF DISSIMILAR HISTORY.

Since sedimentation goes on most actively along the borders of the great land masses of the globe, it is mainly a function of continental growth and decline. Its most important relation is with the shore-line, for the latter marks the boundary along which the process goes on. On the one side materials are being continually prepared to be carried away; on the other they are being deposited. To rising or sinking of the land with reference to the sea, or to the continual advance or retreat of the shore-line, are to be ascribed all the widespread changes in the character of the deposits thrown down in any particular place, and it is the variations in level, chiefly, that give rise to the intricate succession of lithologically different layers.

The immediate causes for the changes between the relations of the land and sea areas are to be sought in orogenic and epeirogenic movements. As the two kinds of movements cannot be readily separated practically, and as it is of small advantage to separate them theoretically, the results produced may be all regarded as arising from the one cause, from mountain-making forces.

The greatest and most abrupt changes in sedimentation, and consequently in lithological, stratigraphical and faunal, and in fact all characters, are those connected directly with diastatic changes, producing depression of some land areas below sea level, and the uprising of other districts above the level at which they once stood, forming those great surface features called mountains. Geological chronology, therefore, is believed to find a rational basis in the same processes that are involved in the genesis of mountain systems, and it is proposed to mark off the leading subdivisions of geological time, and stratigraphical succession, in accordance with the cycles of orographic development, calling the classification a systematic arrangement by mountains, and the principle orotaxis. By the term mountain is meant, not alone those geographic features which at the present time are so conspicuous on the surface of the earth, but also all of those structures which have in the past been prominent characters in the surface relief, and

which are still geotectonically mountains, though they have been completely base-leveled, and have been long since buried beneath later sediments. With these old mountains the cycles of orogenic development are properly regarded as beginning at the time when the strata were compressed, and as extending through the periods when they were bowed up, then planed off nearly to sea level, and submerged perhaps, until degradational products were deposited upon their upturned edges. The record of the completed cycle of mountain-making is the measure of orotaxial chronology. The division planes cutting the geological column into systems, series, or smaller groups are, theoretically as well as actually, the lines of unconformities. In the case of the more extensive, they no doubt represent base-leveled surfaces or peneplains

In all cases, great or small, the erosion plane and period of degradation of the land has its equivalent in the sea, in an accumulation of sediments. An ancient plane of unconformity, as it is now open to observation, may pass gradually into a great plane of sedimentation. In the grander unconformities, in which the plain of discordant sedimentation represents essentially an old peneplain, the corresponding stratum which was deposited in the sea area is usually a limestone. In fact, most limestone formations are now looked upon as representing deposition during periods when the land adjoining was a graded surface, or a plain of faint relief lying but little above sea level This being the case, all unconformities have much greater significance than heretofore suspected.

These surfaces of unconformity and their representative great planes of sedimentation are the only absolute datum planes from which the measurement of formations can be estimated. Theoretically the formation is generally considered as a fixed and clearly defined unit; in practice it is found to be ill-defined and incapable of definition in any but the vaguest terms. But from the datum plane of the unconformity a new sequence of strata begins, sharply and clearly set off from the formations below. Many, and perhaps most, of the sharp lines of divisions are now effaced over much of the existing land surface, but in this respect the record is not more imperfect than any other, for the formations themselves have been swept away. The longer a land area has remained above sea level, the greater is the liability of the records of the earlier events being lost. Over other districts in which

sedimentation has gone on without material interruption during an even protracted orogenic movement, the line for delimiting the various formations may not always be clearly discernible and might not, with existing data, be recognized; but with the detailed mapping of the country by the various official geological surveys, the materials are either at hand, or soon will be, for sharply defining all the places where the lines of demarkation should be properly drawn. These lines, when once made out, and when once properly considered, are as far-reaching, and as universal in application, as those of any classificatory system probably ever can be made. Where the sequence of events has been continuous, lines drawn through the very middle of a rock succession are not entirely arbitrary, but in accord with the history more clearly recorded elsewhere.

While orogenic movements vary greatly, both in intensity and extent, they are probably as wide reaching in their effects as any one regional force can be that is of use in geological chronology. They may be rarely or never continental — certainly not world-wide in extent — but the different parts of a given continent may be successively and repeatedly affected so that a given region may be subjected to the influences from several centers of activity. The records of these movements for the continents thus overlap and interlock in such a manner that from all a moderately complete network is evolved, upon which may be arranged, in proper chronological position, the minor episodes. With the comparison of different continents, the difficulties are greater, but there are some lines which surely can be found that are common to both, just as in the case of the various provinces of a single continent.

In coming down to the lesser stratigraphical groups, as the series, the stages and their subdivisions, the various subordinate or local criteria of correlation may be applied in defining the several members. The leading considerations are the geographical distribution, the lithological characters, the stratigraphical delimitation, and biological definition. In dwelling upon the main characters of each stratigraphical unit, all the physical history must be incorporated.

In proposing the term orotaxis, denotive of the essential feature in the scheme of geological classification and chronology above outlined, it is not with the idea of advancing an hypothesis that is entirely new, but rather of formulating into a

connected whole a number of views which have long been known, somewhat vaguely as a rule, perhaps, yet which are in fact, to a certain degree at least, the real foundation of systematic geology. It is the christening of the scheme with a title in which the governing causes of sedimentation are recognized, in which the elements rendering possible any systematic arrangement are brought into due prominence, and in which an old principle is greatly extended in its application, and is relieved of much of that which has so long overshadowed it.

In general geological classification, about the only attempt in which the orotaxial principle has shown itself in the past, is in demarkation of the grand divisions or systems, and the events are commonly referred to as geological revolutions. The nearest approach to the practical application of the idea, in some of its phases, has been by Irving,* in his work on the pre-Cambrian crystallines of the Northwest, in which unconformities are given great prominence; by McGee,† in his investigations of the coastal plain deposits of the middle Atlantic slope, in which similarity of origin, or homogeny, is the governing factor; and by Davis‡ and others in their physiographic work, in which periods of base-leveling are made the all-important features in the cycles of land degradation and the consequent sedimentation in adjoining seas.

CONCLUSIONS.

Proceeding upon the suggestions that have just been made, the principles of general correlation may be more clearly shown by the construction of a chart (plate vi) representing a section across the North American continent, in an east and west direction, as for instance from Richmond to San Francisco. In a diagrammatic representation of this kind, the geographic provinces are cut off by vertical lines, and the geological systems by horizontal ones, the latter being separated by distances approximately proportional to the estimated time interval. The skeletal chart stands for continuous and uninterrupted geological history of the continent and the stratigraphical succession from the earliest to the latest formations. In the proper places are indicated some of the principal physical

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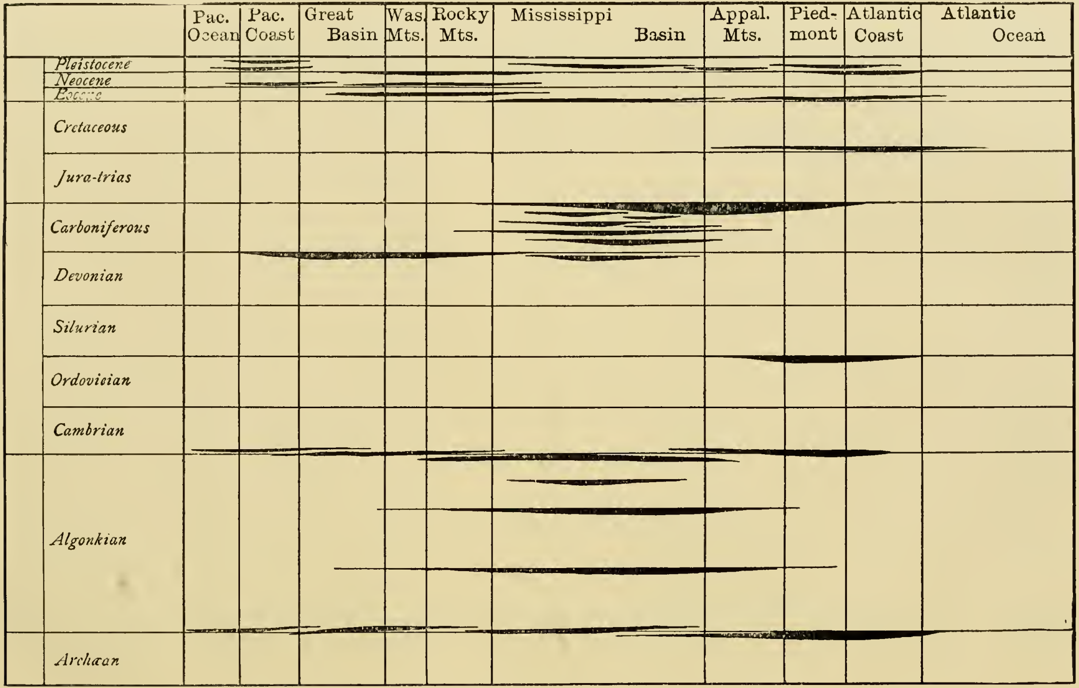
*U. S. Geol. Sur., 7th Ann. Rept., p. 378, 1888.

†Am. Jour. Sci., (3), Vol. XL, pp. 36-41, 1890.

‡Nat. Geog. Mag., Vol. I, pp. 183-253, 1889.



Graphic representation of principal Orogenic movements in America.

breaks in sedimentation, or the leading cycles of mountain-making activity. These are essentially the horizons of unconformities, and they are extended laterally across as much territory as they approximately affected. A large number of less important unconformities are known. The whole, when thus arranged, forms an interlocking series of absolute datum planes by which may be paralleled all geological sections.

The present scheme is based upon our present plan of geological chronology. In the main this is unchanged, though there is, doubtless, a considerable element of error that will have to be eliminated as the more exact determinations of parallelism are made out. The larger divisions or systems may be left very nearly the same as they are now. The minor subdivisions which cannot now be brought into juxtaposition, can readily be placed in the general scale. This appears to be one of the advantages recommending such a scheme.

A PRELIMINARY LIST OF THE MOSSES OF IOWA.

BY T. E SAVAGE.

The mosses together with the Hepaticæ or liverworts constitute the group of plants known as the Bryophytes. This group is distinguished from the Thallophytes, by the fact that they present two modes of reproduction, the sexual and the asexual, which occur in regular alternation. This gives rise to what is called alternation of generations. Most bryophytes also exhibit a very fair differentiation as between stem and leaf.

The spore of the moss, on germinating, produces a many-celled, branching filament containing chlorophyl, the protonema. From the protonema are developed colorless rhizoids, which penetrate the substratum, and buds which produce the stem or leafy axis of the plant. At the apices of the stems, or of the small lateral branches, are borne the sexual organs, the antheridia and archegonia. Mosses may be monœcious, the antheridia and archegonia being produced on the same plant, or diœcious, the sexual organs being borne on separate plants. The protonema and the leafy stem with the sexual organs make up the sexual generation.

After the egg-cell or oösphere, which is produced within the archegonium, is fertilized by the motile antherozoid cell from the antheridium, it begins at once to divide, and develops rapidly into a capsule and stalk. During this growth the lower portion of the stalk is pressed downward into the end of the stem from which the nourishment for the asexual phase of the plant existence is derived, as in the case of a parasite. The growing embryo soon ruptures the wall of the archegonium near the base, the upper part of which is carried up on top of the capsule, where it is called the calyptra. This stalked capsule or sporogonium, constitutes the asexual generation. It is less conspicuous than the sexual phase, and is developed exclusively for the production of the spores.

Mosses may be distinguished from the liverworts by the fact that in the sexual generation of the former, protonemal filaments are always well developed, on which the leafy axis is produced which shows no sign of dorsi-ventral structure.

The rhizoids of mosses are usually made up of a row of cells instead of a single cell as in the Hepaticæ. The mature capsule of the mosses opens by a special lid, the operculum, which is covered by the calyptra. The columella is also present, at least in the early stages of the development of the capsule, and the mouth of the capsule usually shows a well developed peristome, consisting of one or more rows of minute teeth. Elaters, which are produced by the liverworts, are absent in the mosses.

Mosses grow in shallow water, on the ground in swamps and ditches, in open fields and in shady places, on decayed logs and stumps in the woods, on rocky ledges and loose stones along streams, and on the bark of living trees. They vary in size from the small forms, a few millimeters in length, to large, floating or creeping plants, which attain a length of several inches.

At no season of the year will the collector fail to be rewarded in his search for mosses. Some fruit in early spring, some in midsummer, some in the late autumn, and some may be found in fine fruit during the warmer periods of midwinter.

The following list of seventy-eight species and varieties represents but an incomplete collection from a few points in the state. It is given with the hope that it may bring more to the notice of our collectors a group of plants that has hitherto been undeservedly neglected. In its preparation, the writer is

indebted to Professor Macbride and Professor Shimek, of the State University, for kind assistance; to Mrs. Britton, of the Columbia University, and Professor Cheney, of Madison, Wis., for verification of doubtful forms, and also to the collectors whose names appear on the following pages. Sets of all the mosses noted below are in the herbarium of the State University of Iowa, and also in the collections of the writer. Specimens of the more common species of this list have been collected and used in the laboratories of the university during many years. More particularly, Miss Annette Slotterbec, in 1888, collected and identified some forty specimens. But on the whole it has been deemed better to record the collection of such material only as has been gathered for the preparation of this paper.

Group BRYOPHYTA.

Class *Musci*. Order *Bryaceæ*. True mosses.

Series I. ACROCARPI.

Tribe PHASCEÆ.

1. *Phascum cuspidatum* Schreb. Growing on clay hillsides exposed to the sun; common in early spring. Johnson county, March 13, 1897, *T. E. S.*

Tribe WEISIEÆ.

2. *Astomum nitidulum* Schimp. On wet, marshy ground, growing among grass and weeds; rare. Johnson county, March 21, 1897, *P. C. Myers.*

3. *Weisia viridula* Brid. Very common on the ground, fruiting throughout the year. Henry county, December 29, 1896, and Johnson county, March 13, 1897, *T. E. S.;* Pottawattamie county, May, 1897, *J. E. Cameron.*

4. *Dicranella varia* Schimp. On clay banks in open and exposed places; not common Johnson county, October 17, 1896, *T. E. S.*

5. *Dicranella heteromalla* Schimp. Grows on the ground, often associated with species of Barbula; common. Johnson county, October, 1895, *Professor Shimek;* Johnson county, October 17, 1896, *T. E. S.;* Muscatine county, November 15, 1897, *Shimek & Savage.*

6. *Dicranum flagellare* Hedw. Growing on sandy hillsides, in the shade; not commonly distributed over the state. Muscatine county, November 15, 1897, *T. E. S.*

7. *Dicranum scoparium* Hedw. Common on low, sandy ground, in shaded places. Johnson county, October 10, 1896, *T. E. S.;* Muscatine county, November 8, 1897, *Professor Shimek;* Delaware county, September, 1897, *J. E. Cameron.*

8. *Fissidens minutulus* Sulliv. Very rare; found only in the deep ravines at Wildcat Den; on sandstone rocks near the water. Muscatine county, November 15, 1897, *Shimek & Savage.*

9. *Fissidens taxifolius* Hedw. On damp, shaded banks near streams; not common; found only at one point. Henry county, December 28, 1896, *T. E. S.*

10. *Leucobryum vulgare* Hampe. Plants whitish and spongy like sphagnum, with capsule and peristome resembling a Dicranum; common on low, shaded grounds. Johnson county, 1895, *Professor Shimek;* Johnson county, March 13, 1897, *T. E. S.;* Delaware county, September, 1897, *J. E. Cameron;* Muscatine county, November 15, 1897, *Shimek & Savage*

11. *Ceratodon purpureus* Brid. Common everywhere in exposed places on dry ground. Johnson county, May 10, 1896, and Cedar Rapids, May 15. 1896, *Professor Shimek;* Johnson county, October 10, 1896, *T. E. S.;* Pottawattamie county, May, 1897, *J. E. Cameron;* Lyon county, July, 1897, *Professor Shimek;* Muscatine county, November 15, 1897, *Shimek & Savage.*

12. *Ceratodon purpureus aristatus* Aust. Leaves narrower than the last, with long excurrent costa; capsule paler in color; not common. Mason City, 1895, *Professor Shimek.*

Tribe POTTIEÆ.

13. *Ditrichum pallidum* Hampe. Not rare; on the ground in dry places. Henry county, March 26, 1897, *T. E. S.;* Muscatine county, November 15, 1897, *Shimek & Savage.*

14. *Ditrichum tortile* Muell. Common on exposed hillsides; often grows associated with *Barbula unguiculata.* Johnson county, March 13, 1897, *T. E. S.;* Delaware county, September, 1897, *J. E. Cameron.*

15. *Desmatodon arenaceus* Sulliv. & Lesq. Rare, collected only on shaded sandstone rocks. Muscatine county, November 15, 1897, *Shimek & Savage.*

16. *Barbula rigida* Schultz. Not common; found only on the dry loess hills of western Iowa. Council Bluffs, November, 1898, *Professor Shimek.*

17. *Barbula unguiculata* Hedw. Common everywhere; growing on the ground or on limestone rocks in damp places.

Armstrong, September 10, 1882, *Professor Shimek:* Johnson county, March 13, 1897, *T. E. S.:* Council Bluffs, September, 1888, *Misses Dubal & Cavanagh:* Council Bluffs, November, 1898, *Professor Shimek.*

18. *Barbula fallax* Hedw. Rather rare; found along the roadside on dry clay ground. Johnson county, September 29, 1896, *T. E. S.*

Tribe GRIMMIEÆ.

19. *Grimmia apocarpa* Hedw. Common on limestone rocks in early spring. Johnson county, March 13, 1897, *T. E. S.*

Tribe ORTHOTRICHEÆ.

20. *Orthotrichum porteri* Aust. Not rare; on dry rocks in the spring, associated with the preceding. Johnson county, March 13, 1897, *T. E. S.*

21. *Orthotrichum brachytrichum* Schimp. Common on the bark of trees; fruiting in early spring. Johnson county, February 3, 1897, *T. E. S.*

22. *Orthotrichum braunii* Bruch. & Schimp. Rare; growing on trees. Found only in Muscatine county, November 15, 1897, *Shimek & Savage.*

Tribe PHYSCOMITRIEÆ.

23. *Pyramidula tetragona* Brid. A very rare species with a limited distribution in the United States; collected only on ledges of quartzite. Lyon county, July, 1897, *Professor Shimek.*

24. *Physcomitrium acuminatum* Bruch. & Schimp. Not rare in southeastern Iowa; growing on low ground, exposed to the sunshine. Cedar Rapids, May 15, 1896, and Johnson county, May 20, 1896, *Professor Shimek:* Johnson county, March 15, 1897, *T. E. S.:* Pottawattamie county, May, 1897, *J. E. Cameron.*

25. *Funaria hygrometrica* Sibth. Common throughout the state; growing on the ground in woods and open places. Johnson county, April 30, 1896; Keokuk, June 2, 1896; Armstrong, June 30, 1896, and Spirit Lake, August 1, 1896, *Professor Shimek:* Johnson county, March 13, 1897, *T. E. S.:* Decorah, March 24, 1898, *P. C. Myers.*

Tribe BARTRAMIEÆ.

26. *Bartramia pomiformis* Hedw. Very common on shaded bluffs bordering streams. Johnson county, April 30, 1896,

Professor Shimek; Johnson county, October 3, 1896, *T. E. S.;* Delaware county, September, 1897, *J. E. Cameron;* Muscatine county, November 15, 1897, *Shimek & Savage.*

Tribe BRYEÆ.

27. *Leptobryum pyriforme* Schimp. Not rare; a very delicate form growing on the ground or damp rocks. Johnson county, March 13, 1897, *T. E. S.;* Muscatine county, November 15, 1897, *Shimek & Savage.*

28. *Bryum intermedium* Brid. Very common everywhere, growing on rocks or on the ground. Johnson county, May 20, 1895; Cedar Rapids, May 15, 1896, and Mason City, July 20, 1896, *Professor Shimek;* Johnson county, October 3, 1896, *T. E. S.;* Pottawattamie county, May, 1897, *J. E. Cameron.*

29. *Bryum argenteum* Linn. Common on low, sandy ground near streams, sometimes occurring on rocks. Johnson county, September 22, 1896, and March 13, 1897, *T. E. S.*

30. *Bryum argenteum lanatum* Bruch. & Schimp. Branches thicker than the preceding, with whiter leaves; capsule more nearly spherical. Johnson county, September 26, 1896, *T. E. S.*

31. *Bryum nutans* Schreb. Not common; growing on the sandy hill-sides near Wildcat Den. Muscatine county, November 15, 1897, *Shimek & Savage.*

32. *Minium cuspidatum* Hedw. One of our most common species; growing in shady woods at the base of trees. Keokuk, July 5, 1897; Johnson county, May 20, 1896, and Mason City, July 7, 1896, *Professor Shimek;* Johnson county, September 26, 1896, *T. E. S.;* Pottawattamie county, May, 1897, *J. E. Cameron;* Lyon county, July, 1897, *Professor Shimek;* Delaware county, September, 1897, *J. E Cameron.*

33. *Minium affine* Bland. Not common; it has been collected at but one point in the state. Decorah, March 24, 1898, *P. C. Myers.*

34 *Aulacomnium heterostichum* Bruch. & Schimp. A beautiful species, growing in thick tufts on the sandy hillsides at Wildcat Den. Muscatine county, November 15, 1897, *Shimek & Savage.*

35. *Timmia megapolitana* Hedw. Easily distinguished by its calyptra persisting near the top of the pedicel; common; on ground. Johnson county, May 20, 1896, *Professor Shimek;* Johnson county, April, 1897, *T. E S.*

Tribe POLYTRICHEÆ.

36. *Catharinea undulata* Beauv. Somewhat rare; on damp ground in shady woods. Johnson county, May 20, 1896, *Professor Shimek:* Johnson county, October 10, 1896, *T. E. S.:* Delaware county, September, 1897, *J. E. Cameron:* Muscatine county, November 15, 1897, *Shimek & Savage.*

37. *Catharinea angustata* Bruch. & Schimp. More common than the last; growing on drier banks in the woods. Johnson county, September 20, 1896, and Henry county, December 29, 1896, *T. E. S.:* Keokuk, June 2, 1897, *Professor Shimek:* Muscatine county, November 15, 1897, *Shimek & Savage.*

38. *Pogonatum brevicaule* Beauv. Not common; stems short, springing from a dark green tangle of branched, filamentous prothalbium; growing on moist banks. Henry county, December 28, 1896, *T. E. S.:* Muscatine county, November 1897, *Shimek & Savage.*

39. *Polytrichum piliferum* Schreb. Rare; the costa of the leaf is prolonged into a long hyaline point. Lyon county, July, 1897, *Professor Shimek:* Decorah, March 24, 1898, *P. C. Myers.*

40. *Polytrichum juniperinum* Willd. Not rare; growing on the ground in rather dry places. Johnson county, October 10, 1886, and Henry county, December 28, 1896, *T. E. S.:* Delaware county, September, 1897, *J. E. Cameron:* Muscatine county, November 15, 1897, *Shimek & Savage.*

41. *Polytrichum commune* Linn. Plants larger than the preceding, with the longer leaves serrate to the base; common in the woods. Johnson county, October, 1896, and Henry county, December 29, 1896, *T. E. S.*

Series II. PLEUROCARPI.

Tribe LESKEACEÆ.

42. *Thelia asprella* Sulliv. A very beautiful moss; common; growing at the base of trees. Johnson county, May, 1896, *Professor Shimek:* Johnson county, September 20, 1896, and Henry county, December 28, 1896, *T. E. S.:* Delaware county, September, 1897, *J. E. Cameron.*

43. *Leskea polycarpa* Ehrh. Common in damp woods along streams: growing on the trunks of trees. Johnson county, October 1, 1896, *T. E. S.*

44. *Leskea obscura* Hedw. Plants smaller than the last, with which it is often associated on trees. Johnson county, May, 1896, *Professor Shimek:* Johnson county, February 3, 1896, *T. E. S.:* Muscatine county, November 8, 1897, *Shimek & Savage.*

45. *Anomodon rostratus* Schimp. A very common moss, growing on stones, on prostrate logs, or at the root of trees, in damp, shady places. Johnson county, September, 1896, *Professor Shimek:* Johnson county, March 13, 1897, *T. E. S.;* Muscatine county, November 15, 1897, *Shimek & Savage.*

46. *Anomodon attenuatus* Hueben. Not rare; growing in loose, wide tufts on rocks and logs, and roots of trees along streams. Johnson county, September, 1896, *T. E. S.;* Muscatine county, November 15, 1897, *Shimek & Savage;* Decorah, March 24, 1898, *P. C. Myers.*

45. *Anomodon obtusifolius* Bruch. & Schimp. Leaves two-ranked and annulus large; common on the trunks of trees near water. Johnson county, September, 1895, *Professor Shimek:* Johnson county, October 17, 1896, *T. E. S.;* Decorah, March 24, 1898, *P. C. Myers.*

Tribe ORTHOTHECIEÆ.

48. *Platygyrium repens* Bruch. & Schimp. Very common in the woods; growing in yellowish green tufts on decayed logs. Johnson county, September, 1896, *Professor Shimek;* Johnson county, October 1, 1896, *T. E. S.:* Delaware county, September, 1897, *J. E. Cameron;* Muscatine county, November 8, 1897, *Professor Shimek:* Decorah, March 24, 1898, *P. C. Myers.*

49. *Pylaisia intricata* Bruch. & Schimp. Not rare; often growing with the last, on trees and decayed logs in shady woods. Johnson county, September, 1896, *Professor Shimek:* Johnson county, October 17, 1896, *T. E. S.;* Delaware county, September, 1897, *J. E. Cameron:* Muscatine county, November 15, 1897, *Shimek & Savage.*

50. *Cylindrothecium cladorrhizans* Schimp. Very common in the woods, on decayed logs or on the ground. Johnson county, May, 1895, and Dallas county, July 7, 1896, *Professor Shimek;* Johnson county, October 17, 1896, and Henry county, December 28, 1896, *T. E. S.;* Fort Dodge, July 5, 1897, *Professor Shimek;* Delaware county, September, 1897, *J. E. Cameron:* Muscatine county, November 15, 1897, *Shimek & Savage:* Decorah, March 24, 1898, *P. C. Myers.*

51. *Cylindrothecium seductrix* Sulliv. Habitat the same as the last, with which it often grows; stems a darker green and branches more terete than C. cladorrhizans; very common. Johnson county, October, 1895, *Professor Shimek;* Johnson county, October 3, 1896, and Henry county, December 29, 1896,

T. E. S.; Lyon county, July, 1897, *Professor Shimek;* Muscatine county, November 15, 1897, *Shimek & Savage.*

52. *Cylindrothecium compressum* Bruch. & Schimp. Not common; growing in damp places near streams, on the ground. Johnson county, May 20, 1896, *Professor Shimek.*

53. *Climacium americanum* Brid. A beautiful moss, very common on damp, shady ledges of rock, or on the ground or decayed logs in damp places. Johnson county, May 20, 1896, *Professor Shimek;* Johnson county, October 3, 1896, and Henry county, December 28, 1896, *T. E. S.;* Delaware county, September, 1897, *J. E. Cameron;* Muscatine county, November 15, 1897, *Shimek & Savage;* Decorah, March 24, 1898, *P. C. Myers.*

Tribe HYPNEÆ.

54. *Thuidium scitum* Beauv. Not uncommon on decayed logs or on the ground in damp places. Johnson county, October, 1895, *Professor Shimek;* Johnson county, March 13, 1897, *T. E. S.*; Muscatine county, November 15, 1897, *Shimek & Savage.*

55. *Thuidium gracile* Bruch. & Schimp. On decayed logs in damp woods; less common than the preceding, from which it may be distinguished by its more turgid and nodding capsule. Muscatine county, November 15, 1897, *Shimek & Savage.*

56. *Thuidium recognitum* Hedw. Not rare on old logs or on the ground in damp, shady places; a very beautiful form, with large, frond-like stems, which are bipinnately branched. Johnson county, 1895, *Professor Shimek;* Johnson county, October 13, 1896, and Henry county, December 29, 1896, *T. E. S.;* Delaware county, September, 1897, *J. E. Cameron;* Muscatine county, November 15, 1897, *Shimek & Savage.*

57. *Thuidium abietinum* Linn. Not common; growing on damp, shaded rocks; rarely found in fruit; the simple stems are pinnately divided into rather thick, nearly equal branches. Decorah, March 24, 1898, *P. C. Myers.*

58. *Brachythecium lætum* Brid. Common in woods and shaded places on the ground; capsule turgid. Johnson county, October, 1895, *Professor Shimek;* Johnson county, October 13, 1896, and Henry county, December 28, 1896, *T. E. S.;* Keokuk, June 2, 1897, *Professor Shimek;* Muscatine county, November 15, 1897, *Shimek & Savage.*

59. *Brachythecium lætum* Brid. On the ground among

grasses a special form occurs; stems longer creeping and leaves longer acuminate than the last. Johnson county, October, 1896, *Professor Shimek.*

60. *Brachythecium acuminatum* Beauv. Common in damp woods, on decayed logs. Easily distinguished by its erect capsule and rudimentary cilia. Johnson county, October, 1894, *Professor Shimek;* Johnson county, September 21, 1896, *T. E. S.;* Delaware county, September, 1897, *J. E. Cameron;* Muscatine county, November 15, 1897, *Shimek & Savage.*

61. *Brachythecium acuminatum setosum* Sulliv. & Lesq. Branchlets slender and plumose; leaves longer than those of the last; habitat the same. Johnson county, October 17, 1896, *T. E. S.*

62. *Brachythecium rivulare* Bruch. A large moss growing in swamps and very wet places; not common. Muscatine county, November 15, 1897, *Shimek & Savage.*

63. *Brachythecium plumosum* Swartz. Rare; growing on damp sandstone rocks and on wet ground. Muscatine county, November 15, 1897, *Shimek & Savage.*

64. *Eurhynchium hians* Hedw. Not rarely found on moist, shaded hillsides. Pedicel very rough. Johnson county, September 29, 1896, *T. E. S.*

65. *Rhynchostegium serrulatum* Hedw. Very common in dry woods on the ground. Leaves two ranked. Johnson county, May, 1896, *Professor Shimek;* Johnson county, October 17, 1896, and Henry county, December 28, 1896, *T. E. S.*

66. *Plagiothecium sylvaticum* Huds. Rare; growing on the ground in deep shade. Johnson county, October 17, 1896, *T. E. S.*

67. *Amblystegium serpens* Linn. Common on decayed logs or on the ground in damp, shady places; stems delicate and densely branching. Johnson county, October 3, 1896, *T. E S.;* Pottawattamie county, May, 1897, *J. E. Cameron;* Fort Dodge, July 5, 1897, *Professor Shimek.*

68. *Amblystegium irriguum* Hook. & Wils. Not rare on wet ground; stems longer and coarser than the last. Johnson county, May, 1896, *Professor Shimek;* Muscatine county, November 15, 1897, *Shimek & Savage.*

69. *Amblystegium adnatum* Hedw. Commonly found on trees or on stones in damp places; rare. Muscatine county, November 15, 1897, *Shimek & Savage.*

70. *Amblystegium riparium* Linn. Very common on decayed

logs in damp woods and along streams; very variable. Armstrong, July 30, 1896, and Spirit Lake, August 1, 1896, *Professor Shimek;* Johnson county, October 10, 1896, *T. E. S.;* Dallas county, July 7, 1897, *Professor Shimek.*

71. *Amblystegium riparium fluitans* Lesq. & James. Not rare; growing in the mud or water on the borders of streams. Mason City, May 15, 1896, *Professor Shimek.*

72. *Campylium hispidulum* Brid. Plants small and prostrate, with deltoid acuminate leaves; common in wet places on logs or roots of trees. Mason City, July 8, 1896, and Johnson county, September, 1896, *Professor Shimek.*

73. *Harpidium aduncum* Hedw. Rare, stems long and floating; growing in water. Johnson county, 1895; and Forest City, July 20, 1896, *Professor Shimek.*

74. *Hypnum imponens* Hedw. Not common; growing on decayed logs and roots of trees in damp woods. Johnson county, August, 1895, *Professor Shimek.*

75. *Hypnum curvifolium* Hedw. Plants large, yellowish-green; leaves very crowded and strongly recurved; not rare on decayed logs in damp woods. Johnson county, October 3, 1896, *T. E. S;* Muscatine county, November 15, 1897, *Shimek & Savage.*

76. *Hypnum haldanianum* Grev. Not common; growing on sandy hillsides. Muscatine county, November 15, 1897, *Shimek & Savage.*

77. *Hylocomium schreberi* Willd. A large moss; not rare on damp, shaded ground; stems red; leaves loosely spreading; orange at base. Henry county, December 29, 1896, and Johnson county, March 13, 1897, *T. E. S.*

78. *Hylocomium triquetrum* Linn. Common on the ground and on rocks in damp, shady places; plants large; leaves squarrose. Henry county, December 28, 1896, *T. E. S.;* Johnson county, May, 1897, *Professor Shimek;* Delaware county, September, 1897, *J. E. Cameron.*

ADDITIONS TO THE BIBLIOGRAPHY OF NORTH AMERICAN LICHENS.

BY BRUCE FINK.

While reading in the botanical library of the University of Minnesota during the summer of 1896, I noticed a number of titles which had escaped Mr. W. W. Calkins, while preparing his bibliography of North American lichens.* These I added to some before noted in my own library and began a careful search which extended through the summers of 1897 and 1898; examining also the general library of the University of Minnesota.

The work was begun simply to find articles for my own use; but knowing the importance of having bibliographies as complete as possible, I have concluded to publish what additions I have been able to find. In the search for titles I have examined complete files of fifteen of our leading American scientific periodicals, have looked through the best general botanical bibliographies and have consulted various miscellaneous writings. Yet, I am sure that some articles have escaped me, as I know too well the difficulties encountered in hunting for articles published in obscure places, and sometimes in papers bearing titles which do not indicate the presence of anything regarding lichens.

Nearly all of the articles listed have been examined, and I have repeated four or five of Mr. Calkins' titles because very imperfectly cited. I have brought my list only to the date of his publication, and in a future paper I shall hope to bring his paper, my additions and any other titles that I may be able to find, together for greater convenience of reference and to continue the work to include the list of papers published since April 15, 1896, the date to which his bibliography extends. I have attempted to follow, in general, the rules of citation of the Madison Botanical congress.

*Calkins, W. W. Bibliography of North American Lichenology, Chicago Acad. Sci. 1: 44-50, April 1896.

LIST OF ARTICLES.

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2. Bessey, C. E. Preliminary List of the Carpophytes of the Ames Flora. Bull. Iowa Agr. College. 141–148. N 1884. Gives a list of twenty-four lichens.

3. ————. The Study of Lichens. Am. Nat. **21**: 666–667. Jl 1887.

4. Eby, Amelia F. Preliminary List of the Lichens of Lancaster County, Pennsylvania. Pamphlet, 5. 29 Ja 1894.

5. ————. Reprint of the Preliminary List of Lichens of Lancaster County, Pennsylvania. Pamphlet, 17. 7 Mr 1894.

6. ————. A List of Lichens and a Partial List of Fungi Collected in Lancaster County, Pennsylvania. Pamphlet, 13. 22 O 1894.

7. Darlington, W. Flora Cestrica, an Herborizing Companion for the Young Botanists of Chester County, Pennsylvania, Philadelphia: pp. 431–456. 1883. 105 species, determined by E. Michener, are enumerated with short descriptions.

8. Eaton, A. Manual of Botany of North America, Albany, 1817. Contains descriptions of some lichens.

9. Eckfeldt, J. W. Notes on the Lichens in the Herbarium of the Philadelphia Academy of Science. Proc. Acad. Sci. Phil.: 342–343. 1886.

10. ————. Some New North American Lichens. Bull. Torr. Bot. Club **16**: 104–106. Ap 1889. Gives six of Dr. W. Nylander's descriptions of new North American lichens.

11. ————. A further enumeration of some Lichens of the United States. Bull. Torr Bot. Club **17**: 255–257. 9 O 1890. Gives descriptions of ten species.

12. ————. A Lichen new to the United States, *Alectoria cetrariza*. Nyl. Bull. Torr. Bot. Club **18**: 257. 8 Au 1891.

13. ————. In list of plants collected by the United States steamer Albatross, in 1887–1891, along the western coast of America, Cont. Nat. Herb. **1**: 70–79. 1892. Lichens by Elkfeldt.

14. ———. Lichens new to North America. Bull. Torr. Bot. Club **21**: 393–396. 29 S 1894. Describes nine new species.

15. ———. In Rand, E. L. and Redfield, J. H. Flora, of Mt. Desert Island, Maine. John Wilson & Son, Cambridge, Mass., 1894 A list of 280 species and varieties of lichens from Mt. Desert and adjacent islands.

16. Farlow, W. G. Memoir of Edward Tuckerman. Pamphlet, read before the National Academy, April, 1887. 14. Judd & Detweiler, printers, Washington, D. C.

17. ———. The Collection of Lichens belonging to the Boston Society of Natural History. Proc. Boston Soc. Nat. Hist. 274-275. 1888. Read, February 17, 1886.

18. Fink, Bruce. Lichens collected by Dr. C. C. Parry in Wisconsin and Minnesota in 1848. Proc. Iowa Acad. Sci. **2**: 137. 1895.

19. ———. Lichens of Iowa (exsiccati). Fayette, Iowa, 1895-1898,—100 sets of 100 to 150 species each, have been distributed in America and Europe.

20. Gray, A. Memoir of Edward Tuckerman. Am. Jour. Sci. and Arts **132**: 1–7. Jl 1886.

21. Green, H. A. A new Lichen. Bot. Gaz. **12**: 115. My 1887. Gives H. Willey's description of *Buellia catawbensis.*

22. Harvey, F. L. Contributions to the Lichens of Maine, I. Bull. Torr. Bot Club **21**: 389-393. 29 S 1894. List of 115 species.

23. ———. Contributions to the Lichens of Maine, II. Bull. Torr. Bot. Club **23**: 7–10. 30 Ja 1896. List of 114 species.

24. Heller, A. A. Preliminary Enumeration of the Lichens of Lancaster County, Pennsylvania. Pamphlet, Lancaster, Pa 15 F 1893.

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29. Michaux, A. Flora Boreali—Americana, sistens characters plantarum, quas in America septentrionali collegit et detexit, Paris, 1803. Mentions twenty-one species from Carolina and Canada, seven new.

30. Meyer, E. De plantis Labradoricis libritres, Lipsiæ, 1830. Mentions seventeen lichens.

31. Müller, J. Lichenogische Beiträge, Lichenes aus Texas, Flora **60**: 77–80. 11 F 1877. Lists 41 species and varieties and describes five of them as new.

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A series of articles of various titles, of which the above numbers at least give names or descriptions of North America lichens. Some are described as new.

33. ———————. Lichens Oregonensis in Rocky Mountains, Washington Territory, insula Vancouver et territories vicinis Americæ occidentalis a cl; Dr. Julio Roell anno præter lapso lecti et a cl; Dr. Dieck communicata, quos determinavit. Flora **72**: 362–366. 20 Jl 1889. Lists eighty-one species and gives a description of a new variety.

34. ———————. Lichenes Exotice. Hedwigia **34**: 139–145. Je 1895. Some mention of North American lichens.

35. Nylander, W. Lichenes collecti in Mexico a Fr. Müller. Flora **41**: 377–379. 28 Je 1858. Determination of 110 Mexican species.

36. ———————. Expositio Pyrenocarpeorum. Andecavis, 1858. North American species mentioned.

37. ———————. Synopsis Methodica Lychenum; Paris, 1858–1860. Contains numerous references to North American lichens.

38. ————. Observationes paucæ circa Scripta lichenologica recentissima. Flora **43**: pp. 41-44. 21 Ja 1860. Comments on Tuckerman's "Supplement to an Enumeration of North American Lichens."

39. ————. Conspectus Squamariarum. Flora **44**: pp. 716–718. 7 D 1861. Mentions North American species.

40. ————. Enumeratio synoptica Stictarum. Flora **48**: 296–299. 23 Je 1865. Mentions North American species.

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42. ————. Arthoniæ novæ Americanæ, borealis. Flora **68**: 311–313. 1 Je 1885. Describes six species.

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44. Petiver, Joc. Pterographia Americana, icones continens Filicum nec non Muscos, Lichenes, Fungos, etc. London, 1712. Refers to a single lichen, *Sticta damæcornis* (Auct.).

45. Plumier, Carol. Filicetum Americanum senfilicum, etc. in America nascent. Paris, 1703. Also mentions *Sticta damæcornis* (Auct.).

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47. Pound, R. The Algae, Fungi and Lichens. Am. Nat. **23**: 178. F 1889.

48. Rau, E. A. A Lichen new to the United States. Jour. of Mycology **4**: 20. F 1888. A note on *Trypethelium heterochrous.*

49. Sargent, F. L., in How to collect certain Plants. Bot. Gaz. **11**: 142. Je 1886. By several writers; Mr. Sargent treating lichens.

50. ————, Guide to the Recognition of the Principal Orders of Cryptogams and the commoner and more easily distinguished New England Genera, with Glossary. Pamphlet,

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52. ————. About Lichens, Pop. Sci. News **26**: 50–52, 65–67. Ap, My 1892. (Illustrated Figs. 17.) A popular article for beginners in the study of lichens.

53. ————. A Key to the North American Species of Cladonia. Cambridge, Mass., 1893. A quarto blue-print.

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62. ————. A further enumeration of some New England Lichenes. Boston Jour. Nat. Hist. **3**: 281–306. 1841. Gives sixty-eight species and varieties.

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THE FLORA OF SOUTHERN IOWA.

BY T. J. AND M. F. L. FITZPATRICK.

II.

On June 20, 1898, the first writer of this article started overland from Lamoni to Council Bluffs, in company with Prof. J. T. Pence. The route taken passed through the west side of Decatur county to Hopeville, in the southwest part of Clarke county, thence bearing west to Afton in Union county, on to Creston in the same county. As near as practicable the line of the Chicago, Burlington & Quincy railway was followed through Adams county, bearing southward with the railway to Villisca and northward to Red Oak in Montgomery county. From Red Oak a nearly northerly direction was taken until into Pottawattamie county, then westward to Wheeler and northwestward to Carson, where the overland trip, as far as this article is concerned, ended. Carson was reached June 24th. The five days of the journey were filled with frequent stops in order to collect by the wayside and from adjoining groves and fields. A week was spent at Carson collecting in the immediate vicinity and in Wheeler's grove.

On July 25th, the writer in company with J. P. Anderson, an ex-student of the Nebraska State University, left Lamoni in a covered wagon for an overland trip to Nebraska City, Neb. The route taken beyond Decatur county, was through the southern portions of Ringgold, Taylor, Page and Fremont counties, passing through in succession Caledonia, Redding, Blockton, Bedford, Shambaugh, Coin, Riverton, through the hills west of Riverton and across the valley to Nebraska City, Neb. An entire week was taken for the journey. Material was collected from the waysides and adjoining streams or occasionally covering the rougher uplands. From Nebraska City

we passed northward through Otoe county and stopped in Cass county, Neb., opposite McPaul, Iowa. Here two weeks were spent drying material and collecting on the Nebraska side of the river or on the Iowa side around McPaul. Wabonsie slough, which is mostly the remains of a lake about two miles north of McPaul, gave us many good specimens.

On August 25th we started from Nebraska City on our return. The route chosen was northwesterly across the valley and through the hills to Sidney in Fremont county, thence eastward to Clarinda, Page county; on across Taylor county to Mt. Ayr, in Ringgold county, the road scarcely varying a mile north or south from a due east and west line, the entire distance from Sidney to Mt. Ayr. From Mt. Ayr we turned southerly, toward Lamoni, arriving on the 18th of August.

The following list of species is the result of the trips here described and the additional species found in Decatur county since our last paper was written. The specimens are deposited in the private herbarium of T. J. and M. F. L. Fitzpatrick. The list is by no means complete but represents very well the flora of the region for the period of time covered. The order Leguminosæ is fairly well represented, midsummer being the time of its greatest development, while the great order Compositæ has only fairly started by the latter part of August. The spring flora had passed out by the time we began work.

The rectangle formed by the six counties, Union, Adams, Montgomery, Ringgold, Taylor and Page, presents much in common. A great portion of this region is an expanse of rolling prairie. Level ground is rarely seen save in the narrow bottoms or highest uplands. The ground near the streams rolls heavily, but gradually reduces to long swells as we go farther from the streams. Much of the land appears as long narrow ridges running parallel with the streams and flanked at sharp intervals with small lateral ones. The ridges are of the typical Kansas drift, covered with a thin black or blackish soil, while the valleys are alluvium, deposited from overflows of the streams or carried down from the uplands by surface wash.

Grand river and its tributaries cross diagonally the eastern portion of Union county, rolling southeasterly; Ringgold county is drained by the west fork of the Grand and Platte rivers, and their tributaries, rolling southwesterly. The southeastern portion of Union county is drained by the same

system. The divide, separating these two systems, passes southeasterly across the center of Union county, thence southward near the line of Decatur and Ringgold counties. Adams county rolls southwesterly and is drained by the Nodaway system, which system also drains the eastern portion of Montgomery and Page counties, the river system flexing from a southwesterly to a southerly direction, in the southeastern portion of Montgomery county. Taylor county has the Platt river system, and rolls to the southward.

The western portion of Montgomery county is drained by the Nishnabotany system, which runs southwesterly, crossing the northeastern portion of Page county; thence bearing westward to Riverton, in Fremont county, where the different systems of the Nishnabotany unite into a single stream; the whole system lies east of the loess hills which border the Missouri river bottoms. The river systems of the rectangle, in general, flow southwest, except in the extreme eastern portion, where they flow southeast. The whole county is cut into numerous north and south divides by the many tributaries of the Platt.

Throughout this rectangle of six counties, the flora presents a complex nature, which is common throughout the region. The native flora is much restricted in extent, though it persists in many portions where the primeval sod has as yet been unfurrowed. The waysides, the narrow strips along the railway, and portions next the back settlements, still grow the original prairie grass and the accompanying flora, while many similar tracts are continuously pastured, and present little flora, except here and there a thicket.

In this region the western flora is passing eastward and the eastern flora westward. Many species, on their tramps in opposite directions, seem to have met in this region, and established themselves, and to have become an integral part of the flora. Examples of the western forms are *Lactuca pulchella* D. C., *Plantago aristata* Mx., *Solanum rostratum* Dunal., *Hordeum pusillum* Nutt., and many others as will be seen from the list. Among those moving westward are the Lepidiums, *Brassica nigra* Koch., *Capsella bursa-pastoris* Moench., *Xanthium canadense* Mill., *Ambrosia artemisæfolia* L., and *A. trifida* L., *Anthemis cotula* D. C., *Datura stramonium* L. and *D. tatula* L , all of which are becoming conspicuous in the waste land throughout the region. The prairie portions yield Silphiums, Helianths, Liliums, Psoraleas, Anemones, Ceanothus, Asters, and

Solidagos, the two latter genera appearing in their best development a month later than the time of our explorations. The bottoms of the small rivers or streams frequently have marshes, or long ponds, formed from old river beds. Here may be found *Typha*, *Sagittaria*, *Lemna*, *Sparganium*, and other water plants hereafter listed. The woods were composed of elms, oaks, cottonwoods, linn, an occasional sycamore, and great abundance of willows in the lowlands. The older trees have mostly been pressed into use for local purposes. The woods are largely made up of young trees. Upland thickets are common and are mostly composed of hazel, red haws, sumac, plum, buckthorn, bittersweet, and shrubby oaks. The flora is much restricted by agricultural operations, which yearly reduce the amount of free ground for the native flora, while more careful culture renders difficult the existence of the introduced flora which, however, takes refuge in waste lots and along fence-ways and borders. The native flora takes refuge in the railway right of way, where the plants have been enjoying a brief respite, but will, ere long, either be compelled to turn tramps or cease to exist.

The counties west of the rectangle have many species peculiar to that portion of Iowa. The bluffs bordering the Missouri river valley are composed of a remarkable series of loess hills. The flora of these hills includes Yuccas, Legumes, and grasses that are not found anywhere else in Iowa. The valley of the river has quite a number of introduced plants, common enough now, and which are migrating, and destined to extend from here eastward and become a source of trouble to farmers.

In the preparation of this paper we are indebted to Mr. J. P. Anderson, of Lamoni, Iowa, for constant assistance as a collector. To R. I. Cratty, F. Lamson-Scribner, and the officers of the Missouri Botanical Garden, we are under obligations for determinations of difficult species.

We present the results of our labors, and hope they are worthy as a contribution to a better knowledge of the flora of this portion of Iowa.

LAMONI, Iowa, January 1, 1899.

RANUNCULACEÆ.

Clematis virginiana L. Union, Ringgold, and Page counties. Thickets and waysides; frequent.

C. pitcheri T. & G. Union, Fremont, and Pottawattamie counties. Thickets; frequent.

Anemone cylindrica Gray. Union, Ringgold, Fremont, Adams, Montgomery, and Pottawattamie counties. Prairies, waysides; frequent.

A. virginiana L. Ringgold, Page, and Fremont counties. Woods; frequent.

A. pennsylvanica L. Ringgold and Pottawattamie counties. Prairie; frequent.

Thalictrum purpurascens L. Union, Ringgold, Page, Taylor, Fremont, Adams, and Pottawattamie counties. Open woods; frequent.

Ranunculus multifidus Pursh. Decatur county. A few specimens found in a moist locality.

Aquilegia canadensis L. Ringgold and Pottawattamie counties. Woods; common.

Delphinium tricorne Mx. Clarke, Union, and Decatur counties. Fields and woods; moist places; common. Many specimens were found with double flowers, the two upper petals, as usual, and six others, the lower sepal spurred similar to the upper, but with a smaller spur. Specimens with six or seven petals were also found.

D. azureum Mx Clarke, Union, Adams, Montgomery, and Pottawattamie counties. Prairies; common.

MEMISPERMACEÆ.

Menispermum canadense L. Union, Ringgold, Page, Taylor, Fremont, and Pottawattamie counties. Woods; common.

BERBERIDACEÆ.

Podophyllum peltatum L Union and Ringgold counties. Rich woods; common.

NYMPHÆACEÆ.

Nymphæa tuberosa Paine. Fremont county. Common in Wabonsie slough.

CRUCIFERÆ.

Arabis canadensis L. Page county. Woods; infrequent.

A. dentata T. & G. Decatur county. One specimen found.

Nasturtium sinuatum Nutt. Fremont county. This species is a very common weed in the Missouri river bottoms.

N. sessiliflorum Nutt. Decatur and Page counties. Low, wet places; frequent.

N. palustre D. C. Union county. Moist places; common.

N. armoracia Fries. Adams county. Waste places; common.

Erysimum cheiranthoides L. Decatur county. One specimen found.

Sisymbrium officinale Scop. Clarke, Union, Adams, Montgomery, Pottawattamie, Ringgold, Taylor, and Fremont counties. A common weed in waste places.

Brassica nigra Koch. Ringgold, Page, Montgomery, and Pottawattamie counties. Fields and waste places; common.

Capsella bursa-pastoris Moench. Clarke, Union, and Ringgold counties. A common weed.

Lepidium virginicum L. Clarke, Adams, and Pottawattamie counties. Waste places; common.

Raphanus sativus L. Taylor county. A few escapes.

CAPPARIDACEÆ.

Cleome integrifolia T. & G. Fremont county. A common weed in the Missouri river bottoms.

CISTACEÆ.

Helianthemum majus (L.) B. S. P. Union and Taylor counties. Prairies, frequent. We have heretofore listed this as *H. canadense* Mx. *Lechea major* Mx. of our previous lists is only a form of this species.

Lechea stricta Legget. Johnson county. Listed before as *L. minor* L.

VIOLACEÆ.

Viola palmata L. Fremont county. A few found in low places.

Viola cucullata Ait. Union, Ringgold, and Pottawattamie counties. Fields and woods; common.

Viola pubescens Ait. Pottawattamie county. Woods; frequent.

CARYOPHYLLACEÆ.

Saponaria officinalis L. Ringgold, Taylor, and Fremont counties. Waysides; infrequent.

Silene stellata Ait. Ringgold, Page, Fremont and Pottawattamie counties. Woods; frequent.

S. noctiflora L. Fremont county. A few found by the wayside.

PORTULACACEÆ.

Portulaca oleracea L. Pottawattamie county. Waste places; common.

HYPERICACEÆ.

Hypericum ascyron L. This species was frequent in Otoe and Cass counties, Nebraska, opposite Fremont county, Iowa. It was not noticed eastward of the Missouri river.

H. prolificum L. Johnson county. Frequent, locally.

H. mutilum L. Johnson county.

H. cistifolium Lam. Fremont county. Several specimens were obtained.

H. maculatum Walt. Ringgold and Taylor counties. Open places; frequent.

MALVACEÆ.

Althæa rosea Cav. Decatur county. Occasionally an escape.

Malva crispa L. Decatur county. Several specimens obtained in waste places.

M. rotundifolia L. Union, Taylor, and Fremont counties. Waste places; common.

Sida spinosa L. Page and Fremont counties. Waste places; frequent.

Abutilon avicennæ Gaertn. Union, Adams, Pottawattamie, Ringgold, Page, Taylor, and Fremont counties.

Hibiscus militaris Cav. Fremont county. Wabonsie slough and elsewhere; frequent; also in Cass county, Nebraska, opposite Fremont county.

H. trionum L. Ringgold and Fremont counties. Fields; frequent.

TILIACEÆ.

Tilia americana L. Union, Montgomery, Ringgold, and Fremont counties. Low woods; frequent.

LINACEÆ.

Linum sulcatum Riddell. Ringgold and Taylor counties. Prairies; frequent.

GERANIACEÆ.

Oxalis violacea L. Union county. Common.

O. stricta L. Clarke, Union, Taylor, Fremont and Pottawattamie counties. Fields and woods; common.

Impatiens pallida Nutt. Taylor and Fremont counties. Wet woods; frequent.

I. fulva Nutt. Fremont county. With the preceding; infrequent.

RUTACEÆ

Xanthoxylum americana Mill. Ringgold, Page, Taylor, Fremont, Montgomery, and Pottawattamie counties Thickets; common.

CELASTRACEÆ.

Celastrus scandens L. Ringgold, Taylor, Fremont, and Pottawattamie counties. Woods; frequent.

Euonymus atropurpureus Jacq. Page and Pottawattamie counties. Woods; frequent.

RHAMNACEÆ.

Rhamnus lanceolata Pursh. Ringgold, Page, Adams, Montgomery, and Pottawattamie counties. Upland thickets; common.

Ceanothus americanus L. Ringgold, Taylor, Page, and Montgomery counties. Prairies; infrequent.

C. ovatus Desf. Adams, Montgomery, and Pottawattamie counties. Prairies; common.

C. ovatus pubescens T. & G. Pottawattamie county. Common.

VITACEÆ.

Vitis riparia Mx. Clarke, Adams, Montgomery, Pottawattamie, Ringgold, Page, Taylor, and Fremont counties. Woods and thickets; common.

V. cinerea Eng. Page and Fremont counties. Woods; infrequent.

Cissus ampelopsis Pers. Fremont county. Common in woods bordering the Missouri river.

Ampelopsis quinquefolia Mx. Adams, Montgomery, Pottawattamie, Ringgold, Page, and Fremont counties. Thickets; common.

SAPINDACEÆ.

Aesculus glabra Willd. Ringgold, Taylor, and Union counties; rich woods; frequent.

Acer dasycarpum Ehrh. Clarke, Adams, Montgomery, Ringgold, and Fremont counties; moist woods and artificial groves; common.

Negundo aceroides Moench. Union, Adams, Montgomery, Pottawattamie, Ringgold, Taylor, and Fremont counties; rich woods; common.

ANACARDIACÆ.

Rhus glabra L. Clarke, Union, Adams, Montgomery, Pottawattamie, Ringgold, Taylor, Page, and Fremont counties; thickets; common.

R. toxicodendron L. Clarke, Adams, Montgomery, Pottawattamie, Ringgold, Page, and Fremont counties; thickets and waysides; frequent. *R. radicans* L. of the new nomenclature.

POLYGALACEÆ.

Polygala senega L. Ringgold and Taylor counties; prairies; common.

P. verticillata L. Decatur and Fremont counties; dry soil; frequent. The variety, *ambigua* Gray, of our preceding papers, belongs here.

LEGUMINOSÆ.

Baptisia leucophæa Nutt. Clarke, Union, Adams, and Ringgold counties. Prairies; frequent.

B. leucantha T. & G. Adams, Clarke, Union, Ringgold, Pottawattamie, and Taylor counties. Prairies; common.

Crotalaria sagittalis L. Fremont county. A few specimens found. Very common in dry, open, upland woods, Otoe county, Nebraska.

Trifolium pratense L. Clarke, Union, Adams, Montgomery, Pottawattamie, Ringgold, and Fremont counties. Waysides; common.

T. reflexum L. Union county. One specimen found on river bank.

T. repens L. Clarke, Union, and Pottawattamie counties. Waysides; common.

T. hybridum L. Adams county. Waste places; infrequent.

Melilotus officinalis Willd. Fremont county. Waste places; frequent.

M. alba Lam. Clarke, Union, Adams, Pottawattamie, Montgomery, Taylor, and Fremont counties. Waysides; common.

Medicago sativa L. Fremont county. Waste places; infrequent.

Psoralea tenuiflora Pursh. Union and Ringgold counties. Prairies; frequent.

P. argophylla Pursh. Clarke, Union, Adams, Montgomery, Pottawattamie, Taylor, and Page counties. Prairies; common.

P. esculenta Pursh. Fremont county. Loess hills, probably frequent.

Amorpha canescens Nutt. Clarke, Adams Montgomery, Pottawattamie, Page, Ringgold, Taylor, and Fremont counties. Waysides; common.

A. fruticosa L. Clarke, Adams, Montgomery, Pottawattamie, Ringgold, Taylor, and Fremont counties. Sloughs and along streams; common.

A. microphylla Pursh. Decatur county. Dry upland woods infrequent.

Dalea laxiflora Pursh. Fremont county. Loess hills, common.

Petalostemon violaceus Mx. Ringgold, Taylor, and Fremont counties. Prairies; frequent.

P. candidus Mx. Ringgold, Page, and Fremont counties. Prairies; frequent.

Robinia pseudacacia L. Taylor and Montgomery counties. Appearing as escapes; frequent.

Astragalus canadensis L. Ringgold, Taylor, Page, and Fremont counties. Damp soil; common.

Oxytropus lamberti Pursh. Fremont county. Loess hills, common.

Glycyrrhiza lepidota Nutt. Union, Taylor, and Montgomery counties. Waysides; common.

Desmodium acuminatum DC. Ringgold, Page, and Fremont counties. Rich woods; common.

D. illinoense Gray. Ringgold and Page counties. Prairies; frequent.

D. paniculatum DC. Decatur and Fremont counties. Woods; infrequent.

D. canadense DC. Ringgold and Page counties. Open woods; frequent.

D. dillenii Darlingt. Fremont county. Woods; frequent.

Lespedeza violacea Pers. Ringgold and Page counties. Prairies; frequent.

L. reticulata Pers. Dry, upland woods; infrequent.

L. capitata Mx. Ringgold, Page, and Fremont counties. Dry soil; common.

Apios tuberosa Moench. Ringgold, Taylor, and Fremont counties.

Strophostyles angulosa. Ell. Fremont county. Sandy soil; common.

S. Pauciflorus Watson. Fremont county. Sandy soil; frequent.

Amphicarpæa monoica Nutt. Page county. Dry woods; frequent.

A. pitcheri T. & G. Page and Pottawattamie counties. Woods; frequent.

Cercis canadensis L. Fremont county. Frequent.

Cassia marylandica L Ringgold, Page, and Fremont counties. Rich lowlands; frequent; in some localities forming thickets; found also in Otoe and Cass counties, Nebraska.

C. chamæcrista L. Ringgold, Page, Taylor, Fremont, Montgomery, and Pottawattamie counties; waste places; common.

Gymnocladus canadinsis Lam. Fremont and Pottawattamie counties; low woods; infrequent.

Gledetschia triacanthos L. Adams, Ringgold, Taylor, Page, and Fremont counties.

Desmanthus brachylobus Benth. Fremont county; foot of loess hills and bottoms of the river; common.

ROSACEÆ.

Prunus americana Marsh. Clarke, Union, Adams, Taylor, and Pottawattamie counties; thickets; common.

P. sertina. Ehrh. Union, Adams, Montgomery, Pattawattamie, Ringgold, Page, Taylor, and Fremont counties; woods: frequent.

P. virginiana L. Clarke, Adams, and Pottawattamie counties; low woods; frequent.

Spiræa salicifolia L. Taylor and Page counties; waysides; infrequent.

Rubus occidentalis L. Clarke, Ringgold, Fremont, and Pottawattamie counties; waysides, thickets; frequent.

R. villosus Ait. Union, Ringgold, and Fremont counties; open woods; frequent.

Geum album Gmelin. Ringgold, Page, and Pottawattamie counties.

Potentilla arguta Pursh. Ringgold county; prairies; common.

P. norvegica L. Ringgold county; fields; common,

Agrimonia eupatoria L. Ringgold, and Fremont counties; open woods; common.

A parviflora Ait. Page and Ringgold counties; low prairies; frequent.

Rosa arkansana Porter. Clarke, Union, Adams, Montgomery, Pottawattamie, Ringgold, Page, and Fremont counties; prairies; common.

Pyrus coronaria L. Clarke, Union, Adams, Montgomery, Pottawattamie, Ringgold, Page, and Taylor counties; thickets; common.

P. malus L. Union, Page, Adams, Montgomery, Pottawattamie, and Ringgold counties; waysides; frequent; appearing mostly as low shrubs.

Cratægus coccinea L. Clarke, Adams, Taylor, and Pottawattamie counties; thickets; common.

C. crus-galli L. Clarke and Page counties; woods; frequent.

Amygdalus persica L. Ringgold, Taylor, Page, and Fremont counties; waysides; waste places; frequent; an escape from cultivation.

SAXIFRAGACEÆ.

Heuchera hispida Pursh. Union and Adams counties; prairie; frequent.

Parnassia caroliniana Mx. Johnson county; frequent locally.

Ribes gracile Mx. Clarke, Union, Adams, Pottawattamie, and Fremont counties; woods; common

R. floridum L'Her. Taylor county; a clump by the wayside.

CRASSULACEÆ.

Penthorum sedoides L. Ringgold and Taylor counties; damp soils; common.

HALORAGEÆ.

Myriophyllum scabratum Mx. Ringgold county; common in a lake near Delphos. In Wabonsie slough, in Fremont county, a deep water form was found that is taken to be this species.

Callitricha heterophylla Pursh. Decatur county; a few specimens found in moist localities. This is a rare plant for Iowa, and even a rare genus. The only other species we have is *C. verna* L., of Muscatine county, collected by F. Reppert.

LYTHRACEÆ.

Ammannia coccinea Rottb. Decatur county; about a dozen specimens found on the margin of a railroad pond near Davis City.

Lythrum alatum Pursh. Union, Adams, Montgomery, Ringgold, Page, Taylor, and Fremont counties; moist soil; common.

Didiplis linearis Raf. Decatur county; a few specimens on the margin of a railroad pond near Davis City; this species was quite common on mud flats of a lake near Benton, Ringgold county, where it was collected in quantity.

ONAGRACEÆ.

Ludwigia polycarpa Short & Peter. Ringgold and Taylor counties. Shallow lakes; frequent.

Gaura biennis L. Fremont county. Fields and waste places; common. By a clerical error *G. coccinea* Nutt. was given for this species in the last Academy report. The localities for southern and northeastern Iowa should be credited to this species.

G. parviflora Dougl. Fremont county. Base of loess hills and in bottoms; frequent.

Oenothera biennis L. Ringgold and Fremont counties. Fields; common.

Circæa lutetiana L. Page, Ringgold, Fremont, and Pottawattamie counties.

CUCURBITACEÆ.

Echinocystis lobata. Taylor, Page, and Fremont counties.

UMBELLIFERÆ.

Cicuta maculata L. Ringgold, Taylor, and Fremont counties. Moist places; common.

Tiedemannia rigida Coult. & Rose. Ringgold county. Wet sloughs; frequent.

Heracleum lanatum Mx. Union and Pottawattamie counties. Rich woods; common.

Pastinaca sativa L. Decatur, Clarke, Union, Adams, Ringgold, Taylor, Page, Fremont, and Johnson counties. Waste places; common.

Pimpinella integerrima. Union county. Woods; frequent.

Polytænia nuttallii DC. Ringgold and Montgomery counties; prairies; a few specimens found.

Cryptotænia canadensis DC. Union, Ringgold, and Pottaawattamie counties; woods; common.

Sium cicutæfolium Gmelin. Ringgold county; wet soil; frequent.

Zizia aurea Koch. Johnson and Page counties; low grounds; common.

Osmorrhiza brevistylis DC. Fremont county; woods; frequent.

O. longistylis DC. Fremont county; woods; frequent.

Eryngium yuccæfolium Mx. Montgomery, Pottawattamie, Ringgold, Taylor, and Page counties; prairies; common.

Sanicula marylandica L. Ringgold and Pottawattamie counties; woods; common.

CORNACEÆ.

Cornus asperifolia Mx. Taylor, Fremont, Montgomery, and Pottawattamie counties; thickets; common.

C. sericea L. Adams county; low places; common.

C. paniculata L'Her. Ringgold and Pottawattamie counties.

C. alternifolia L. Johnson county; one shrub, from which several specimens were collected, is known.

CAPRIFOLIACEÆ.

Sambucus canadensis L. Clarke, Union, Adams, Montgomery, Pottawattamie, Ringgold, Taylor, Page, and Fremont counties. Low grounds; common.

Viburnum pubescens Pursh. Decatur county. Upland thickets; frequent locally.

V. lentago L. Union and Decatur counties. Low ground, along streams; frequent.

V. prunifolium L. Johnson county. Low grounds; infrequent.

V. dentatum L. Johnson county. Wooded ravines; infrequent.

Triosteum perfoliatum L. Union, Adams, Pottawattamie, Ringgold, and Page counties. Woods; common.

Symphoricarpos vulgaris Mx. Clarke, Union, Adams, Montgomery, Pottawattamie, Lucas, Monroe, Ringgold, Taylor, Page, and Fremont counties. Upland woods and prairies; common.

S. occidentalis Hook. Fremont and Pottawattamie counties. Base of loess hills; common.

Lonicera sullivantii Gray. Fremont county. Woods; a few collected.

RUBIACEÆ.

Houstonia angustifolia Mx. Taylor and Fremont counties. Prairies and loess hills; common.

Galium concinnum T. & G. Union and Page counties. Woods; common.

G. circæzans Mx. Fremont and Pottawattamie counties. Woods; common.

COMPOSITÆ.

Vernonia noveboracensis latifolia Gray. Ringgold county. Pastures; common.

Eupatorium purpureum L. Ringgold, Page, and Pottawattamie counties. Woods; common.

Liatris punctata Hook. Fremont county. Loess hills; common.

L. scariosa Willd. Ringgold and Fremont counties. Prairies; common.

L. pycnostachya Mx. Ringgold, Taylor, and Page counties. Prairies; common.

L. squarrosa Willd. Taylor and Page counties. Prairies; common.

Grindelia squarrosa Dunal. Fremont county. Waste places; frequent.

Solidago rigida L Fremont county. Woods; frequent.

S. ulmifolia Muhl. Taylor county. Woods; frequent.

S. missouriensis Ait. Ringgold, Page, Fremont, Decatur, and Johnson counties. Upland woods; frequent.

S. serotina Ait. Taylor county. Low places; common.

Boltonia asteroides L'Her. Ringgold and Taylor counties. Wet soil; frequent.

Aster sericeus Vent. Ringgold, Taylor, Page, Fremont, Montgomery, and Pottawattamie counties. Prairies; common.

A. multiflorus Ait. Ringgold and Taylor counties. Waysides; frequent.

A. lævis L. Johnson county.

Erigeron strigosus Muhl. Clarke county. Fields; common.

E. divaricatus Mx. Ringgold and Fremont counties. Pastures; common.

E. canadensis L. Page and Fremont counties. Waste places; common.

E. annuus Pers. Union and Pottawattamie counties. Waste places; common

Silphium perfoliatum L. Ringgold, Taylor, Page, Fremont, Montgomery, and Pottawattamie counties. Low places; frequent.

S. integrifolium Mx. Ringgold, Taylor, Page, Fremont, Montgomery, and Pottawattamie counties. Prairies; common.

S. laciniatum L. Clarke, Union, Adams, Fremont, Montgomery, and Pottawattamie counties. Prairies; common.

Parthenium integrifolium L. Ringgold county. Prairies; common.

Iva xanthiifolia Nutt. Fremont county. River bottoms; common.

Ambrosia artemisiæfolia L. Clarke, Union, Adams, Montgomery, Pottawattamie, Ringgold, Taylor, Page, and Fremont counties. Waste places; common.

A. trifida L. Clarke, Union, Adams, Montgomery, Pottawattamie, Ringgold, Taylor, Page, and Fremont counties. Waste places; common.

A. psilostachya DC. Fremont county. Waste places; common.

Xanthium canadense Mill. Ringgold, Fremont, and Pottawattamie counties. Waste places; common.

Heliopsis lævis Pers. Decatur and Fremont counties. Upland woods; infrequent.

H. scabra Dunal. Taylor, Page, Fremont, and Montgomery counties. Prairies; common.

Echinacea angustifolia DC. Clarke, Adams, Montgomery, Pottawattamie, Ringgold, and Fremont counties. Prairies; frequent.

Rudbeckia triloba L. Ringgold county. Woods; common.

R. laciniata L. Ringgold county. Low woods; common.

R. subtomentosa Pursh. Johnson county. Prairies; frequent.

Lepachys pinnata T. & G. Ringgold, Taylor, Page, and Fremont counties. Prairies; common.

Helianthus annuus L. Union, Pottawattamie, Ringgold, Page, and Fremont counties. Waste places; frequent.

H. rigidus Desf. Ringgold, Taylor, Page, and Fremont counties. Prairies; frequent.

H. grosse-serratus Mart. Fremont county. Low places; common.

H. hirsutus Raf. Ringgold county. Woods; common.

Actinomeris squarrosa Nutt. Ringgold, Page, and Fremont counties. Low woods; frequent.

Coreopsis palmata Nutt. Clarke, Union, Adams, Montgomery, Pottawattamie, and Page counties. Prairies; common.

C. tripteris L. Ringgold and Taylor counties.

Helenium autumnale L. Taylor and Fremont counties.

Dysodia chrysanthemoides Lag. Union, Ringgold, Taylor, Page, and Fremont counties. Waste places; common.

Anthemis cotula DC. Clarke, Union, Adams, Montgomery, Pottawattamie, Ringgold, Taylor, and Fremont counties. Waste places; common.

Achillea millefolium L. Clarke, Union, Montgomery, Pottawattamie, Decatur, and Ringgold counties. Fields and upland woods; common; pink, flowered forms are frequently found in Decatur county, in upland woods.

Artemisia ludoviciana Nutt. Union, Adams, Montgomery, Pottawattamie, Ringgold, Taylor, Page, and Fremont counties. Waysides and fields; common.

A. annua L. Decatur county. Waste places; common in one locality.

Cacalia atriplicifolia L. Union, Pottawattamie, Ringgold, Taylor, and Fremont counties. Prairies; frequent.

C. tuberosa Nutt. Union, Adams, Pottawattamie, Ringgold, and Taylor counties. Prairies; common.

Arctium lappa L. Clarke, Adams, Pottawattamie, Ringgold, Taylor, and Fremont counties. Waste places; common.

Hieracium longipilum Torr. Taylor county. Prairies; frequent.

H. scabrum Mx. Ringgold county. Woods; frequent.

Prenanthes aspera Mx. Ringgold county. Waysides; frequent.

Lygodesmia juncea Don. Fremont county. Loess hills; common; this species is spreading eastward and is becoming frequent in the cultivated fields.

Taraxacum officinale Neber. Clarke, Union, Adams, Montgomery, and Ringgold counties. Fields and waste places; common.

Lactuca integrifolia Bigel. Decatur, Ringgold, and Taylor counties. Fields and waysides; frequent.

L. scariola L. Decatur, Taylor, Page, and Fremont counties. Waste places; frequent.

L. canadensis L. Ringgold county. Waysides; frequent.

L. floridana Gaertn. Johnson, Van Buren, and Decatur counties. Fields; frequent.

L. pulchella Bigel. Montgomery, Pottawattamie, and Fremont counties. Waste places; common.

Lobeliaceæ.

Lobelia syphilitica L. Taylor, Page, and Fremont counties. Moist places; frequent.

L. spicata Lam. Union and Adams counties. Fields; common.

Campanulaceæ.

Specularia perfoliata A. DC. Union county. Rare.

Campanula americana L Taylor, Page, and Fremont counties. Rich woods; common.

PRIMULACEÆ.

Steironema ciliatum Raf. Fremont county. Woods; frequent.

S. lanceolatum Gray. Ringgold county. Frequent in a swampy locality.

APOCYNACEÆ.

Apocynum androsaemifolium L. Union county. Waysides and fields; frequent.

A. cannabinum L. Clarke, Montgomery, Pottawattamie, Ringgold, and Taylor counties. Fields and waste places; frequent.

ASCLEPIADACEÆ.

Asclepias tuberosa L. Clarke, Union, Montgomery, Ringgold, Taylor, and Page counties. Fields; common.

A. incarnata L. Ringgold, Page, and Fremont counties. Wet soil; frequent.

A. cornuti Decaisne. Clarke, Adams, Pottawattamie, Ringgold, and Taylor counties. Fields; common; the authority for this species was wrongly given as DC. in the last report.

A. sullivantii Englm. Taylor and Page counties. Bottoms; frequent.

A. obtusifolia Mx. Union, Adams, and Montgomery counties. Waysides; frequent.

A. meadii Torr. Adams county. Prairie; infrequent.

A. purpurascens L. Union and Ringgold counties. Infrequent.

A. verticillata L. Ringgold, Taylor, Page, Fremont, and Pottawattamie counties. Fields and open woods; common.

Acerates longifolia Ell. Ringgold and Taylor counties. Prairies; common.

A viridiflora Ell. Clarke county. Prairies; frequent.

GENTIANACEÆ.

Gentiana andrewsii Griseb. Decatur county. Prairies; infrequent.

G. alba Muhl. Taylor county. Prairie woods; infrequent.

POLEMONIACEÆ.

Phlox pilosa L. Union, Adams, Montgomery, and Pottawattamie counties. Prairies; common.

P. divaricata L. Pottawattamie county. Rich woods; common.

HYDROPHYLLACEÆ.

Ellisia nyctelea L. Union county. Damp localities; common.

BORRAGINACEÆ.

Echinospermum virginicum Lehm. Page county.

Lithospermum latifolium Mx. Pottawattamie county.

Onosmodium carolinianum DC. Union, Adams, Montgomery, and Fremont counties. Pastures; common.

CONVOLVULACEÆ.

Convolvulus sepium L. Union, Adams, Montgomery, Pottawattamie, Ringgold, Taylor, Page, and Fremont counties. Waysides; borders of fields; common.

C. arvensis L. Decatur, Taylor, and Fremont counties. Waste places; frequent.

Cuscuta glomerata Choisy. Taylor county. Low places; frequent.

SOLANACEÆ.

Solanum nigrum L. Ringgold, Page, and Fremont counties.

S. carolinense L. Taylor and Fremont counties. Waste places; frequent.

S. rostratum Dunal. Page and Fremont counties. Waste places; fields; becoming frequent.

Physalis angulata L. Fremont county. A few found.

P. philadelphica Lam. Page and Fremont counties. Fields; frequent.

P. lanceolata Mx. Adams and Pottawattamie counties. Open woods; waysides; frequent.

Lycium vulgare Dunal. Page county. Waste places; infrequent.

Nicandra physaloides Gaertn. Fremont county. In fields; infrequent.

Datura stramonium L. Ringgold, Taylor, Page, Fremont, and Montgomery counties. Waste places; common.

D. tatula L. Ringgold county. Waste places; common.

SCROPHULARIACEÆ.

Verbascum thapsus L. Clarke, Montgomery, Pottawattamie, Ringgold, Taylor, Page, and Fremont counties. Fields; waste places; common.

Linaria vulgaris Mill. Clarke and Page counties. Waste places; frequent.

Scrophularia nodosa marylandica Gray. Ringgold and Taylor counties. Open woods; frequent.

Pentstemon grandiflorus Nutt. Fremont county. Loess hills; frequent.

Mimulus ringens L. Ringgold county. Wet places; frequent; white flowered forms were found.

M. alatus Ait. Decatur county. Wet banks; infrequent.

Gratiola virginiana L. Ringgold county. Rich woods; frequent.

Ilysanthes riparia Raf. Ringgold county. Wet banks· common.

Veronica virginica L. Ringgold and Taylor counties. Prairies and woods; common.

Seymeria macrophylla Nutt. Decatur and Page counties. Upland woods; common.

LENTIBULARIACEÆ.

Utricularia vulgaris L. Fremont county. Frequent in Wabonsie slough.

PEDALIACEÆ.

Martynia proboscidea Glox. Taylor county. Waysides; infrequent.

ACANTHACEÆ.

Ruellia ciliosa Pursh. Clarke, Ringgold, Taylor, and Page counties. Waysides; common.

VERBENACEÆ.

Verbena urticæfolia L. Ringgold and Taylor counties. Fields and waste places; common.

V. hastata L. Clarke, Union, Pottawattamie, Ringgold, and Page counties.

V. stricta Vent. Ringgold and Fremont counties.

V. bracteosa Mx. Union, Fremont, and Pottawattamie counties. Fields and waste places; common.

Lippia lanceolata Mx. Fremont county. Wet places; frequent.

Phryma leptostachya L. Page and Fremont counties. Rich woods; frequent.

LABIATÆ.

Teucrium canadense L. Page and Ringgold counties. Low grounds; frequent.

Mentha viridis L. Taylor county. Waysides; infrequent.

Lycopus sinuatus Ell. Fremont county. Low places; frequent.

Pycnanthemum lanceolatum Pursh. Ringgold county. Waysides; frequent.

P. linifolium Pursh. Ringgold county. Prairies; frequent.

Hedeoma pulegioides Pers. Page and Fremont counties. Woods; common.

H. hispida Pursh. Decatur county. Dry, upland woods; common.

Monarda fistulosa L. Ringgold, Taylor, Page, and Fremont counties. Woods; common.

M. punctata L. Jefferson county.

Lophanthus scrophulariæfolius Benth. Fremont county. Woods; frequent.

L. nepetoides Benth. Ringgold, Page, and Fremont counties. Woods; frequent.

Salvia lanceolata Willd. Decatur, Page, and Fremont counties. Waysides; frequent.

Nepeta cataria L. Ringgold, Page, Fremont, and Pottawattamie counties. Waste places; common.

N. glechoma Benth. Clarke and Page counties. Waste places, frequent.

Scutellaria versicolor Nutt. Decatur county. Rich woods; frequent.

S. parvula Mx. Ringgold county. Prairies; frequent.

Brunella vulgaris L. Union, Pottawattamie, Ringgold, Page, and Fremont counties. Open woods; common.

Physostegia virginiana Benth. Fremont county. Wet, low soil; infrequent.

Leonurus cardiaca L. Decatur and Fremont counties. Waste places; frequent.

Marrubium vulgare L. Fremont county. Waysides; scarce.

Stachys palustris L. Union and Montgomery counties. Wet soil; common.

S. aspera Mx. Ringgold county. Low places; frequent.

PHYTOLACCACEÆ.

Phytolacca decandra L. Fremont county. Waysides; infrequent.

PLANTAGINACEÆ.

Plantago rugelii Dec. Ringgold county. Low woods; common.

P. aristata Mx. Ringgold, Montgomery, and Pottawattamie counties. Wayside and waste places; frequent.

NYCTAGINACEÆ.

Oxybaphus nyctagineus Sweet. Union county. Waste places; frequent.

O. hirsutus Sweet. Taylor county. Waysides; infrequent.

O. angustifolius Sweet. Page, Taylor, and Fremont counties. Prairies; infrequent.

O. albidus Choisy. Union county. Waysides; infrequent; the same as *Allionia albida* Walt.

ILLECEBRACEÆ.

Anychia capilalcea DC. Ringgold, Page, Fremont, and Pottawattamie counties. Woods; frequent.

AMARANTACEÆ.

Amarantus retroflexus L. Page and Fremont counties. Waste places; common.

A. albus L. Page county. Waste places.

A. blitoides Watson. Fremont county. Waste places.

CHENOPODIACEÆ.

Chenopodium hybridum L. Ringgold and Fremont counties. Waste places; frequent.

Cycloloma platyphyllum Moq. Fremont county. Sandy soil; frequent.

Atriplex patulum hastatum Gray. Taylor county. Waste places; infrequent.

POLYGONACEÆ.

Rumex crispus L. Clarke county. Waste places; frequent.

R. acetosella L. Pottawattamie county. Waste places; frequent.

Polygonum virginianum L. Ringgold and Page counties. Rich woods; common.

P. aviculare L. Ringgold, Fremont, and Pottawattamie counties. Waste places; common.

P. erectum L. Clarke and Union counties. Waste places; common.

P. convolvulus L. Decatur county. Waste places; frequent.

P. muhlenbergii Watson. Ringgold and Fremont counties. Wet places; frequent.

Fagopyrum esculentum Moench. Page and Pottawattamie counties. Waste places; frequent.

F. tataricum (L.) Gaertn. Decatur county. Waste places; one specimen found.

ARISTOLOCHIACEÆ.

Asarum reflexum ambiguum Bicknell. Decatur, Appanoose, Ringgold and Page counties. Rich woods; common.

A. acuminatum (Ashe) Bicknell. Johnson county. Rich woods; frequent. This and the preceding species have heretofore been confused with *asarum canadense* L.

SANTALACEÆ.

Commandra umbellata Nutt. Page county.

EUPHORBIACEÆ.

Euphorbia serpens H. B. K. Fremont county.

E. maculata L. Ringgold and Fremont counties. Waste places; common.

E. preslii Guss. Ringgold, Page, and Fremont counties. Waste places; common.

E. marginata Pursh. Fremont county. Fields and waste places; common.

E. corollata L. Ringgold, Taylor, Page, Fremont, and Pottawattamie counties. Fields; common.

E. heterophylla L. Decatur county. Bluffs; infrequent.

E. cyparissias L. Decatur and Pottawattamie counties. Waste places; infrequent.

Acalypha virginica L. Page and Fremont counties. Fields and waste places; common.

URTICACEÆ.

Ulmus fulva Mx. Union, Pottawattamie, Ringgold, Taylor, Page, and Fremont counties. Woods; frequent.

U. racemosa Thomas. Decatur county. An infrequent tree along Grand river.

U. americana L. Union, Adams, Montgomery, Pottawattamie, Ringgold, Taylor, Page, and Fremont counties. Low woods; common.

Celtis occidentalis L. Union, Montgomery, Pottawattamie, Ringgold, Page, and Fremont counties. Low woods; frequent.

Cannabis sativa L. Clarke, Union, Adams, Montgomery, Pottawattamie, Ringgold, Taylor, Page, and Fremont counties. Waste places; common.

Humulus lupulus L. Union, Adams, Montgomery, Pottawattamie, Ringgold, Taylor and Fremont counties. Thickets; common.

Morus rubra L. Fremont county. Low woods; frequent.

Urtica gracilis Ait. Clarke, Montgomery, Pottawattamie, Page, and Fremont counties. Low grounds; common.

Laportea canadensis Gaud. Ringgold and Fremont counties. Moist woods; common.

Pilea pumila Gray. Ringgold and Page counties. Damp woods; frequent.

Parietaria pennsylvanica Muhl. Decatur, Union, Page, and Pottawattamie counties. Low woods; frequent.

PLATANACEÆ.

Platanus occidentalis. Page and Fremont counties. Bottoms; frequent.

JUGLANDACEÆ.

Juglans nigra L. Union, Montgomery, Pottawattamie, Ringgold, Page, Taylor, and Fremont counties. Rich woods; common.

Carya alba Nutt. Taylor, Page, Pottawattamie, and Fremont counties. Upland woods; common.

C. amara Nutt. Ringgold, Taylor, Page, Fremont, Montgomery, and Pottawattamie counties. Rich woods; common.

CUPULIFERÆ.

Betula nigra L. Ringgold county.

Corylus americana Walt. Clarke, Adams, Montgomery, Pottawattamie, Ringgold, and Page counties. Thickets; common.

Ostrya virginica Willd. Union and Fremont counties. Bluffs; frequent.

Quercus alba L. Union and Ringgold counties. Woods; common.

Q. macrocarpa Mx. Union, Adams, Montgomery, Pottawattamie, Ringgold, Taylor, Page, and Fremont counties. Woods; common.

Q. bicolor Willd. Ringgold county. Low woods; frequent.

Q. muhlenbergii Englm. Union, Adams, Montgomery, Ringgold, and Fremont counties. Upland woods; frequent.

Q. rubra L. Union, Montgomery, Pottawattamie, Ringgold, Taylor, Page, and Fremont counties. Woods; frequent.

Q. coccinea Wang. Ringgold, Fremont, and Pottawattamie counties. Upland woods; common.

Q. imbricaria Mx. Clarke, Union, and Ringgold counties. Upland woods and thickets; common.

Q. marylandica Muench. Decatur county. Uplands; a frequent shrub associated with *Q. nigra* L.

SALICACEÆ.

Salix nigra Marsh. Decatur, Page, and Fremont counties. Along streams; common.

S. longifolia Muhl. Ringgold, Taylor, Page, and Fremont counties. Rich soil; frequent.

S. humilis Marsh. Taylor county. Dry uplands; frequent.

S. amygdaloides Anders. Page and Fremont counties. Rich low lands; common.

S. cordata Muhl. Page and Fremont counties. Low lands; common.

S. alba vitellina Koch. Decatur county. Becoming frequent.

Populus tremuloides Mx. Union and Ringgold counties. Thickets; frequent.

P. monilifera Ait. Clarke, Union, Adams, Montgomery, Ringgold, Taylor, Fremont, Lucas, and Monroe counties. Low lands; frequent.

CONIFERÆ.

Juniperus virginiana L. Decatur county. A small shrub found in upland woods.

ORCHIDACEÆ.

Spiranthes cernua Richard. Johnson county, several specimens found in moist places; Decatur county, a single specimen found in prairie upland.

S. gracilis Bigelow. Decatur county. About forty specimens found in upland prairie grass.

Cypripedium parviflorum Salisb. Decatur county. Rich woods; associated with *C. pubescens* Willd., but much less frequent.

C. pubescens Willd. Ringgold county. Rich uplands; frequent.

C. spectabi'e Swartz. Jefferson county. Swampy soil; rare. Specimens were transplanted with with good results.

IRIDACEÆ.

Iris versicolor L. Union, Ringgold, and Page counties. Swamps; ponds; frequent.

Belamcanda chinensis Adans. Ringgold, Taylor, and Page counties. Waysides; waste places; becoming frequent.

DIOSCOREACEÆ.

Dioscorea villosa L. Union and Ringgold counties. Thickets; frequent.

LILIACEÆ.

Smilax herbacea L. Union county. Thickets; rich soil; frequent.

S. hispida Muhl. Adams, Ringgold, and Fremont counties. Woods; frequent.

Allium canadense Kalm. Union county. Fields and woods; frequent.

Yucca angustifolia Pursh. Fremont county. Loess hills; common.

Polygonatum giganteum Dietrich. Ringgold, Page, and Pottawattamie counties. Woods; frequent.

Asparagus officinalis. Page, Fremont, and Montgomery counties. Waste places; frequent.

Smilacina racemosa Desf. Union county. Woods; frequent.

Erythronium mesochoreum Knerr. Decatur county. High prairies; common; blooming before *E. albidum* Nutt., and the specimens all flowering ones; the leaves very narrow; found also in Harrison county, Missouri.

Lilium philadelphicum L. Union and Adams counties. Prairies; common.

L. canadense L. Montgomery county. Prairies; frequent.

L. tigrinum Ker. Fremont county. An escape into waste places.

Trillium nivale Riddell. Decatur county. Rocky woods; frequent locally.

Melanthium virginicum L. Union and Adams counties. Damp prairies; frequent.

Zygadenus elegans Pursh. Decatur county. Rich woods; frequent locally.

PONTEDERIACEÆ.

Pontederia cordata L. Ringgold county. Margins of ponds; frequent.

COMMELINACEÆ.

Tradescantia virginica L. Clarke, Union, and Ringgold counties. Prairies and fields; common.

JUNCACEÆ.

Juncus tenuis Willd. Union and Pottawattamie counties. Grassy places; common.

J. torreyi Coville. Fremont county. Damp soil; frequent.

TYPHACEÆ.

Typha latifolia L. Union, Adams, Page, and Fremont counties. Margins of ponds; frequent.

Sparganium eurycarpum Englm. Ringgold county. Ponds; frequent.

S. androcladum (Englm.) Morong. Ringgold county. Ponds; frequent.

ARACEÆ.

Arisæma triphyllum Tor. Pottawattamie county. Rich woods; common.

A. dracontium Schoot. Union, Page, and Pottawattamie counties. Rich woods; frequent.

LEMNACEÆ.

Spirodela polyrrhiza Schleid. Fremont county. Ponds and sloughs; common.

Lemna trisulca L. Fremont county. Ponds and sloughs; frequent.

L. minor L. Decatur, Taylor, and Page counties. Ponds and streams; frequent.

ALISMACEÆ.

Alisma plantago L. Ringgold county. Moist places; frequent.

Sagittaria variabilis Engl. Ringgold and Taylor counties. Ponds; common.

S. graminea Mx. Fremont county. Common in mud flats or shallow water.

NAIADACEÆ.

Potamogeton fluitans Roth. Common in Wabonsie slough.

CYPERACEÆ.

Cyperus speciosus Vahl. Ringgold county.

C. esculentus L. Montgomery and Fremont counties.

Eleocharis ovata R. Br. Ringgold county.

E. acicularis R. Br. Fremont county. Margins of ponds; common.

Scirpus lacustris L. Fremont county. Ponds; common.

S. fluviatilis Gray. Decatur county. Frequent in one locality.

S. atrovirens Muhl. Montgomery county.

Carex lupulina Muhl. Page county.

C. vulpinoidea Mx. Union, Adams, and Montgomery counties. Moist soil; common.

C. rosea Schkur. Pottawattamie county.

C. cephalophora Muhl. Pottawattamie county.

C. cristatella Britton. Adams county.

GRAMINEÆ.

Spartina cynosuroides Willd. Ringgold, Page, Taylor, and Fremont counties. Wet soil; common.

Panicum sanguinale L. Page and Fremont counties. Fields and waste places; common.

P. virgatum L. Taylor county. Low prairies; frequent.

P. glabrum Gaud. Decatur county.

P. lanuginosum Ell. Union county. Waysides; frequent.

P. macrocarpon Le Conte. Union county. Woods; frequent.

P. crus-galli L. Ringgold, Page, and Fremont counties. Waste places; common.

Setaria glauca Beauv. Ringgold, Page, and Fremont counties. Waste places; common.

S. viridis Beauv. Page, Pottawattamie, and Fremont counties. With the preceding.

S. italica Kunth. Page county. Waysides; frequent.

Cenchrus tribuloides L. Fremont county. Sandy shores; common.

Zizania aquatica L. Ringgold and Page counties. Ponds; infrequent.

Tripsacum dactyloides L. Adams, Ringgold, and Taylor counties. Wet places; frequent.

Andropogon scoparius Mx. Decatur county. Uplands and woods; frequent.

Crysopogon nutans Benth. Taylor county. Prairies; frequent.

Phalaris canariensis L. Decatur county. Waste places; streets; infrequent.

Aristida oligantha Mx. Taylor county. Dry soil; frequent.

Stipa spartea Trin. Union, Adams, and Montgomery counties. Prairies; frequent.

Muhlenbergia mexicana Trin. Decatur county. Low places; common.

M. sobolifera (Muhl.) Frin. Decatur and Fremont counties. Infrequent.

Phleum pratense L. Clarke, Union, Adams, Montgomery, Pottawattamie, Ringgold, Taylor, Page, and Fremont counties. Fields and waysides; common.

Alopecurus geniculatus L. Ringgold county. Wet places; frequent.

Bouteloua hirsuta Lag. Fremont county. Loess hills; common.

B. racemosa Lag. Ringgold, Taylor, Page, and Fremont counties. Waysides; frequent

Eragrostis major Host. Ringgold, Page, and Fremont counties. Waste places; common.

E. purshii Schrader. Fremont county.

Melica mutica Walt. Union county. Woods; infrequent.

Dactylis glomerata L. Page county.

Glyceria nervata Trin. Union and Adams county. Low prairies; common.

Bromus secalinus L. Adams county. Fields; frequent.

Bromus ciliatus purgans Gray. Pottawattamie county.

Agropyrum spicatum R. & S. Montgomery and Taylor counties. Prairies; infrequent.

Hordeum jubatum L. Clarke, Union, Adams, and Montgomery counties. Waste places; common.

H. pusillum Nutt. Adams, Montgomery, and Pottawattamie counties. Waste places; waysides; becoming frequent.

Elymus striatus Willd. Decatur, Pottawattamie, Page, and Fremont counties. Woods; frequent.

E. virginicus L. Ringgold county.

E. canadensis L, Ringgold, Taylor, and Fremont counties Waysides; frequent.

Asprella hystrix Willd. Decatur, Ringgold, Page, and Pottawattamie counties. Woods; frequent.

EQUISETACEÆ.

Equisetum arvense L. Union and Fremont counties. Moist soil; common.

E. lævigatum Braun. Adams, Union, Montgomery, and Pottawattamie counties. Uplands; waysides; frequent.

FILICES.

Adiantum pedatum L. Ringgold, Page, and Fremont counties. Rich woods; common.

Cystopteris fragilis Bernh. Union, Page, Pottawattamie, and Fremont counties. Rich woods; common.

Onoclea struthiopteris Hoffm. Decatur county. Rich woods; infrequent.

OPHIOGLOSSACEÆ.

Botrychium virginianum Swartz. Pottawattamie county. Rich woods; frequent.

EXTENSION OF COMPLEX ALGEBRA TO THREE-FOLD SPACE.

BY T. PROCTOR HALL.

Taking rectangular coördinates in a plane, let x, y, be unit vectors along the axes of X, Y, respectively; and let A be any unit vector from O in the plane, making an angle a with X.

Let i be a rotor such that i^n rotates any vector, A, through n. 90° in the positive direction. Then

$$i\,x=y.$$
$$i^2\,A=-A$$
$$\therefore\ i^2=-1.$$

Equating vectors from O:

$$\begin{aligned} A&=x\cos a+y\sin a.\\ &=(\cos a+i\sin a)\,x.\\ &=e^{ia}\,x, \text{ (by expansion in series).}\end{aligned}$$

A vector (A) is here considered to be composed of three distinct components or factors; a unit direction (x), a length (which, for the sake of simplicity, is here considered unity), and a rotor ($\cos a+i\sin a$, or e^{ia}) which has rotated the vector from unit position (x) to any other position (A) in the plane.

The product of two vectors is

$$\begin{aligned} A_1\,A_2&=(\cos a_1+i\sin a_1)(\cos a_2+i\sin a_2)\,x.x.\\ &=[\cos(a_1+a_2)+i\sin(a_1+a_2)]\,x.\\ &=e^{\,i(a_1+a_2)}\,x.\end{aligned}$$

Since x is unity in every one of its capacities, $x\,x=x$, as given above.

The unit vector, x, is a factor of every term of this algebra, and may be dropped, leaving an algebra of rotors only, which

has the laws of operation of ordinary algebra, and which combines with it to form an algebra of tensors and rotors—the ordinary complex algebra.

The kinds of number involved in this algebra are:

(1) reals, a, b, c, ...

(2) plane imaginaries, ia, ib, ...

(3) the plane complex, $z=a+i\,b$.

Next let the xy-plane be the equatorial plane of a sphere of which Z is the pole. Let the power of the rotor i be extended so as to rotate any vector, whether in the xy-plane or not, about the z-axis. Let j be a new rotor, such that j^m rotates any vector through m. 90° in a direction from the plane of x, y, toward the pole z.

By means of these two rotors i^n, j^m, a vector may be turned from the unit position (x) to any other position (A); and the order of the rotations is indifferent.

$$j\, i^n\, x = i^n\, j\, x = j\, x = z.$$
$$j^2\, A = -A$$
$$\therefore j^2 = -1.$$

It follows that j^m may be expressed in the forms $\cos b + j \sin b$, and e^{jb}. Any unit vector, A, is therefore of the form

$$A = (\cos a + i \sin a)(\cos b + j \sin b)\, x$$
$$= e^{ia+jb}\, x.$$

From either of these forms the product or the quotient of two vectors is evident.

Dropping x, as before, and introducing tensors we obtain a tensor-rotor algebra which, *when the i and j binary factors are kept separate*, has the laws of operation of common algebra, and has many of the advantages of a vector algebra without its limitations.

The most general quantity in this algebra is the double complex

$$(a+i\,b)\,(c+j\,d),$$

in which a, b, c, d, are connected by one relation. The double complex may be expressed in the form

$$(a+i\,b)\left(1+j\frac{c}{\sqrt{a^2+b^2}}\right),$$

which is identical with

$$a+i\,b+j\,c.$$

But unfortunately in the latter form it does not obey the laws of common algebra, except in addition, subtraction, and multiplication by reals.

The double complex

$$a+i\,b+j\,c$$

is related to points in three-fold space in the same way that the plane complex

$$a+i\,b$$

is related to points in a plane, and in the form

$$(a+i\,b)\left(1+j\frac{c}{\sqrt{a^2+b^2}}\right),$$

or in the general forms

$$(a+i\,b)\,(c+j\,d),\ e^{r+ia+jb},$$

it may be treated as an ordinary algebraic quantity.

Kansas City University.

A REVIEW OF THE CERCOPIDÆ OF NORTH AMERICA NORTH OF MEXICO.

BY E. D. BALL.

The family cercopidæ, though of world-wide distribution, has comparatively few representatives within our borders, and those few have been but imperfectly known, the literature on the subject being scattered and fragmentary, the generic references often incorrect, and the specific determinations, owing to the extreme variability in color of some species, and the striking similarity of color between others, rendered very questionable. Scarcely one of the more common forms but what has been referred to under at least four different genera and several have more than that number of specific names.

This paper recognizes twenty species as included within our fauna, of which Say described six, Fitch three, Germar one, Uhler four, two were introduced from Europe, and four are here described as new; besides these there have been twenty more described, which have been referred to the first twenty as synonyms or varieties.

Except for the isolated descriptions and a few lists, the first systematic work done on the American species was Uhler's article on the family in the Standard Nat. Hist. (1884).

In 1889 Provancher, in his Hemip. du Canada, published the first synopsis of the group; he divided the family into

three genera (omitting the Issidæ) which were correctly used except that he included *L. 4-angularis* under *Aphrophora;* in his recognition of species he was less fortunate, as all three of his species of *Philænus* were varieties of *spumarius.*

In 1892 Dr. Goding published a synopsis of the genera, together with a bibliographical and synonymical catalogue of the described species; the characterization of the family was simply a translation of Stal's in Hemip. Africana, and the synopsis of the subfamilies and genera an adaptation from the same work. Under the subfamily *Cercopinæ,* he recognized five genera, although Stal himself, the next year after the publication of that synopsis, united four of these genera, and later (Hemip. Mex.), all five; aside from that, however, the only excuse for inserting the fifth genus *(Rhinaulax)* was a MS. note by Dr. Fitch, placing the fabrician species *coccinea* there, while A. & Serv., the authors of all five genera, placed it in the first (*Tomaspis*). Under the *Aphrophorinæ* he separated six genera, although of one (*Clovia*) he made no reference in the catalogue, and of another (*Ptyelus*), he left only two undetermined species of Walker's, one of which was a *Philænus*, and the other a *Lepyronia*, while the genus *Ptyelus*, as characterized by him (from Stal), has not been recognized outside of Africa.

Fowler, in the Biologia, describes a number of new genera and species of Cercopidæ, and has worked out considerable synonomy, of which only the following affects our species: *T. fasciaticollis* Stal=*simulans* Walk. and *bicincta* Say=*rubra* Linn. The first appears to be correct; the second is not, as can be readily seen by comparing *bicincta* with his figures, when it will be seen that it equals *simulans* and not *rubra*, and, being the first described, takes precedence. He also described a number of new species of *Clastoptera* without recognizing *xanthocephala*, *proteus* or *delicata*, specimens of all of which have been examined from Orizaba and other Mexican points, including several varieties, so that no doubt most of his species will fall as synonyms.

In 1896 the author published a revision of the *Clastoptera*, which, with the present paper, completes the family. While working on that paper *P. lineatus* and *bilineatus* were recognized as distinct and attention was called to the generic difference, the venation of each species being figured on the generic plate.

In 1897 Baker, in Notes on the genus *Philænus*, recognized the four species, separated the bibliography of *lineatus* and *bilineatus* and tried to restrict the latter to the west, while he described the eastern representatives as a distinct species *americanus*; an examination of a type and other eastern material shows no grounds, however, for the separation.

During the prosecution of this work I have been placed under special obligations to Mr. Otto Heideman for the loan of a large series of both eastern and western forms, among them the largest collection of eastern *Clastoptera* and of western *Aphrophora* that I have seen; to Professor Bruner for the loan of Nebraska, California, and Mexican material, and to Professors Piper, Gillette, Lintner, Fernald, Morse, C. M. Weed and H. E. Weed, for examination of material from their respective localities; to Professor Uhler for helpful suggestions, and especially to Professor Osborn, under whose supervision the work was originally planned, for the use of his own, the Iowa Agricultural college and V. D. collections, all of them extensive, and (later) the Ohio material; and to Professor Summers for the continuation of the same favors.

Besides the above, my own collection has furnished me with large series from Iowa, the Pacific coast, the West Indies and Mexico.

FAMILY CERCOPIDÆ A. & S.

Body stout, compact; general form oval or elongate; head in nearly same plane as the body; vertex nearly flat, anterior margin rounding or angulate; ocelli, two, placed near the posterior margin; front convex, more er less inflated, transversely ribbed, nearly flat dorsally where it forms a subquadrate insertion in the anterior field of the vertex, from which it is separated by a distinct suture (this portion of the front is considered as part of the vertex and referred to hereafter as the tylus); antennæ short, placed in front of and between the eyes under the margin of the vertex, the two basal joints bead-like, the remainder setaceous, pronotum large, anterior margin straight or angularly rounded, posterior margin short, often deeply emarginate; elytra longer than the abdomen, coriaceous, irregularly reticulated or with two long discoid cells and five or more apical cells; wings with a broad margin beyond the intramarginal vein; posterior coxæ and femora short and stout, posterior tibiæ scarcely longer than the others, round at the base, spatulate at the apex, armed on the outer margin with two stout spurs, the second twice the length of the first; tibiæ and two basal joints of the tarsi terminated with crescent-shaped rows of spines.

The members of this family are readily recognized by the two spurs on the cylindrical hind tibiæ. Some Fulgoridæ

have similar spurs, but the tibiæ are in that case angulate and the antennæ are below instead of between the eyes. All of the N. A. representatives fall in the first two subfamilies of Stal, which may be separated as follows:

SYNOPSIS OF THE SUBFAMILIES.

A. Anterior margin of the pronotum straight; head narrower than pronotum; ocelli placed close together; eyes small, rounded; elytra broad, irregularly rounded at apex. *Cercopinæ* Stål.

AA. Anterior margin of pronotum angulate or rounded; ocelli farther apart, eyes oblong or angulate; head equalling, or almost equalling, the pronotum in width; elytra compressed behind, rarely reticulate *Aphrophorinæ* Stål.

SUBFAMILY CERCOPINÆ.

This subfamily includes large, showy forms in black, red and yellow and is well represented in the tropics. The N. A. forms all belong to a single genus and only a single species occurs north of the Mexican border, and it is more abundant farther south.

GENUS TOMASPIS A. & S.

Tomaspis A. & S. His. des Hemip. p. 561, 1843
Triecphora A. & S. His. des. Hemip. p. 561, 1843.
Monecphora A. & S. His. des. Hemip. p. 562, 1843.
Sphenorhina A. & S. His. des. Hemip. p. 562, 1843.

Head small, much narrower than the humeral angles of the pronotum; front strongly inflated, anteriorly produced, usually beyond the vertex to which it rounds back, transversely ribbed and usually medially carinate; rostrum short, two jointed, scarcely reaching the middle coxæ; vertex much shorter than the pronotum, obtusely angulate, tylus large, eyes small, nearly round; ocelli twice farther from eyes than from each other; pronotum large, anterior margin straight, lateral margins long and strongly oblique, posterior margin straight or emarginate; elytra coriaceous, somewhat flaring, wider than the pronotum, apex rounding equally from both sides, venation obscure, apically reticulate; wings with the intramarginal vein entire, third longitudinal vein forked.

TOMASPIS BICINCTA Say.

Cercopis bicincta Say. Jour. Acad. Nat. Sci. Phil. VI, 303, 1831.
Cercopis ignipecta Harr. (MSS.) Cat. Ins. Mass. —— 1833.
Monecphora bifascia Walk. List Hom. B. M. p. 679, 1851.
Monecphora angusta Walk. List Hom. B. M. p. 680, 1851.
Monecphora neglecta Walk. List Hom. B. M. p. 683, 1851.
Monecphora ignipecta Fitch. (Descrip.) 3d Rep. Ins. N. Y. p. 71, 1856.
Monecphora inferans Walk. List Hom. B. M. Sup. p. 176, 1858.
Sphenorhina simulans Walk. List Hom. B. M. Sup. p. 183, 1858.
Tomaspis fasciaticollis Stal. Stett. Ent. Zeit. XXV, p. 63, 1864.
Tomaspis rubra Fowler. Biol. Cent. Amer., p. 183 (in part).
Tomaspis simulans Fowler. Biol. Cent. Amer. p. 185

Broadly oval, with a narrow, angulate head; deep brown to black with the margins of the vertex, a transverse band across the middle of the pronotum and two across the elytra, red or orange, length 8-10 mm.; width on elytra 5 mm.; vertex broad, depressed two-thirds the length of the pronotum, obtusely angulate, disc sloping, depressed either side the longitudinal carina; front inflated, nearly right angled with the vertex, a single strong median carina; rostrum short, scarcely as long as the front; pronotum, disc convex, one-third wider than long, anterior margin straight, posterior margin roundingly emarginate; elytra convex, coriaceous, over twice longer than wide, much broader than pronotum, outer margins curved, apex broadly rounding; venation obscure, apically reticulate.

Color, dark-chestnut brown to black; a narrow margin all round the vertex and along the median carina, the eyes and ocelli and the lateral margins of the pronotum red; a narrow transverse band across the humeral angles of the pronotum and two slightly wider ones parallel with this, dividing the elytra into three equal portions, red or orange.

Habitat: Specimens are at hand from New York, Massachusetts, Connecticut, Maryland, District of Columbia, North Carolina West Virginia, Florida, Louisiana, Texas, Kansas, and Iowa within our territory, and from Cuba and Mexico from without. It has been reported from Pennsylvania, Askansas, and Georgia, and from Mexico, Jamaica, and several Central American states. It is a very common species in collections from Mexico and the West Indies. In the United States it occurs along the Atlantic slope from New York and Massachusetts south, throughout the gulf states and up the Mississippi valley as far as central Iowa, where it is extremely rare.

This is a somewhat variable species in size, and extremely so in color markings. These forms intergrade and can only be roughly divided as follows:

Form *bicincta*, the typical one, is dark brown with narrow, red bands.

Var. *ignipecta* Fitch, is the dark form where the bands are partly or entirely wanting.

Var. *simulans* Walk., has the bands broader, and creamy yellow in color.

Fowler was evidently misled in placing this species, by Say's remark that *bicincta* resembled *rubra* and *sororia*. It is very likely that those were the only two species that Say was acquainted with, or, at least, the nearest to his species of any that he knew; at any rate, the difference in the front, as shown by Fowler's figures, at once places it with *simulans* and not with *rubra*, and verifies Stal's observation that *fasciaticollis* was "close" to *bicincta*. Walker says of *inferans* that it closely resembles, and may be a local variety of *neglecta*.

Fowler places it as a synonym of *bifascia*, along with *angusta*. The latter was described from Georgia and is an undoubted synonym of *bicincta*, and. if Fowler is correct in uniting the three forms, as it seems, then all four species fall as synonyms of *bicincta*.

SUBFAMILY APHROPHORINÆ Stal.

In this subfamily the species are smaller, more elongate, and, as a rule, rather somber colored. The group is well represented in our territory in both genera and species. Two of the species are European and probably introduced, while many of them are widely distributed, and several extend beyond our borders to the southward.

SYNOPSIS OF THE GENERA.

A. Apex of clavus acute, corium without a terminal membrane.
  B. Anterior margin of the pronotum angulate, ocelli nearer each other than eyes; rostrum long; exceeding the hind coxæ, with three visible segments, the terminal one much the longest. *Aphrophora* Germ.
  BB. Anterior margin of pronotum rounded, ocelli nearly equally distant from eyes and each other; rostrum short, not exceeding middle coxæ; composed of two equal visible segments.
    C. Anterior margin of vertex between front and eyes sharp; whole upper surface densely pubescent, almost hiding sculpturing and venation; submarginal vein of wing interrupted between second and third sectors. *Lepyronia* A. & S.
    CC. Anterior margin of vertex between front and eyes sulcate.
      D. Elytra irregularly reticuled apically. *Philaronia* n. g.
      DD. Elytra with about five apical cells. *Philænus* Stal.
AA. Apex of clavus broadly rounded, corium with a broad terminal membrane; submarginal vein of wing interrupted at apex. (Small globose forms.) **Clastoptera* Germ.

GENUS APHROPHORA Germ.

Vertex obtuse or rectangulate, the apex rounding, anterior margin between the eyes and tylus sharp, ocelli placed close to the posterior margin, nearly twice farther from the eyes than from each other; head with the eyes scarcely as wide as the posterior angles of the pronotum, the anterior and posterior margins nearly parallel, the latter with a median triangular notch between the ocelli, into which fits a slight projection of the pronotum; front convex, inflated, transversely wrinkled except on the median line; rostrum long, with three visible segments, the last one much the longest, extending beyond the hind coxæ; pronotum large, about one-half longer than the vertex, anterior margin distinctly angulate, medially produced into the notched vertex; a distinct median carina extending

*For a synopsis of the Clastoptera see Ia. Acad. Sci. Proc. Vol. III, p. 182.

across both vertex and pronotum: elytra coriaceous, about twice longer than wide, without an appendix, the apex rounding, both veins of corium forking before the middle, forming two long discoid cells; apical cells irregular, usually about five; wings with the third vein from the marginal vein forked and forming a closed apical cell; entire dorsal aspect of insect coarsely and irregularly punctate; male valve wanting.

The members of this genus are all of moderate size, varying from 8 to 12mm. in length, and are strikingly uniform in color and pattern of marking, being grayish or brownish, with two irregular, oblique, dark-margined light bands on the elytra, sometimes obscure and sometimes broken up into spots.

The variation in color and marking is not sufficient to enable one to readily recognize the different species and they are only accurately separated by reference to structural characters, the three most important being the degree of inflation of the front with the corresponding variation of the facial angle, the shape of the terminal ventral segment of the male abdomen and the shape of the male plates, the latter character alone enabling one to readily separate that sex of all our species.

In distribution this genus seems to be limited to the northern hemisphere, and the greater number, if not all the species, occur in the temperate zone. Europe has three species, all of which are widely distributed, while this paper recognizes eight species occurring in the United States and Canada, and Fowler has recently described three new species from Mexico in the Biologia. These latter are all small and are apparently closely related to *4-notata*, the only one of our species that has been taken as far south as our southern border.

Of the species under consideration *4-notata* has the greatest known range, occurring from Ontario to Florida, and west to North Dakota and Iowa. Next to it comes *permutata*, which has been found from Vancouver's island south to central California and eastward to Colorado. Of the others, *parallela* is the only one that has as yet been recorded from widely separated localities, and it is very probable that some of its western records were based on other species.

SYNOPSIS OF THE SPECIES.

A. Elytra very broad, angulate behind, the outer margin strongly curved and with two more or less distinct hyaline areas; general color light-gray or brown; head and pronotum nearly flat, front but slightly inflated, acutely angulate with vertex.

B. Hyaline areas distinct, outer discoid cell its own width from margin. *4-notata* Say.

BB. Hyaline areas indistinct, outer discoid cell not more than half its width from costal margin. *angulata* n. sp.

AA. Elytra elongate, rounding behind, the outer margin broadly curved, without trace of hyaline costal areas: usually with front inflated and the pronotum elevated.

B. Front inflated and produced, meeting the vertex in nearly a right angle; elytra strongly convex, species large, dark.

C. Front much produced, extending distinctly beyond the tylus, to which it rounds back; ovipositor long. *parallela* Say.

CC. Front not extending beyond the vertex, pygofers and ovipositor short, the latter scarcely exserted.

D. Front meeting the vertex at a right angle; plates attingent, finger-like. *permutata* Uhl.

DD. Front meeting vertex at a slightly acute angle; plates broad and short, divergent. *irrorata* n. sp.

BB. Front moderately flat, meeting the vertex at an acute angle; species smaller, narrower, lighter colored.

C. A broad, white median stripe on vertex and pronotum; face and vertex making an angle of about 50 degrees; pygofers long, narrow, ovipositor exserted; plates short, consisting of two rounding lobes *saratogensis* Fh.

CC. At most a narrow, light stripe on vertex, not extending on to pronotum, face and vertex making an angle greater than 50 degrees; pygofers short, ovipositor scarcely longer: plates acute, divergent.

D. Pronotum and elytra strongly maculate, plates divergent from base, suddenly narrowed before the apex. *annulata* n. sp.

DD. Pronotum and elytra nearly unicolorous; plates attingent at base, divergent before the apex, regularly narrowing *signoretii* Fh.

APHROPHORA QUADRINOTATA Say.

A. quadrinotata Say. Jour. Acad. Nat. Sci. Phil. VII, p. 304, 1831.

Dark grayish-brown, with two large hyaline areas on the costal margin of each elytron; closely resembling the European *A. alni* in color and marking, but much smaller and with a longer vertex; length 7–8mm., *width 3–3.5mm.

Vertex nearly flat, one-half longer on middle than at eye, anterior margin rounding, the edge sharp, posterior margin broadly angulate with a distinct notch, median carina distinct; front scarcely inflated, the inflation being about half the length of the long diameter of the eye, forming an acute angle with the vertex; pronotum rather flat, median carina sharp; elytra broad, the costal margin flaring before the middle; whole upper surface of insect coarsely and irregularly punctate.

*Width is always given across the widest part of the elytra when folded.

Color: Vertex, grayish-brown, anterior margin of tylus black-lined, rest of margin light, except against the dark eyes: ocelli red; median carina light; pronotum grayish, the carina and a spot on either side before the middle pale: elytra with the claval areas pale, grayish, corium darker, an oblique hyaline band before the middle, extending from the costal margin to the inner sector, sharply margined behind, fading out in front, behind the middle is an elongate hyaline spot: between these spots is an irregular, dark-brown area, and in well marked specimens another appears in front of the band and a third behind the spot.

Genitalia: Female pygofers about one-third longer than wide, slightly exceeded by the ovipositor; two last segments of the male abdomen elongate narrowed; plates small, twice longer than wide, separated at the base by their own width, their inner margins parallel, outer rounding.

This is the most abundant of the eastern species and is readily recognized by its small size and white markings. A series of several hundred examples show little variation in size or color.

Habitat: Examples have been examined from Ontario, New York, New Hampshire, District of Columbia, Maryland, West Virginia, Georgia, Florida, Iowa and Nebraska, and it has been reported from Ontario, Maine, Massachusetts, Ohio, Illinois, and North Dakota.

APHROPHORA ANGULATA n. sp.

A. angulata Uhl. Mss.

Pale, nearly uniform grayish-brown, two obscure hyaline spots along the costa; larger and more obscurely marked than *4-notata*; length 10mm., width 4mm.

Vertex flat, scarcely longer on middle than next to eye, anterior margin sharp as far as the tylus, which is slightly produced upon the front: median carina weak on the tylus, becoming strong on the posterior margin of the vertex; front weakly inflated, forming an acute angle with the vertex as in *4-notata;* pronotum, anterior third depressed, finely punctate, with a strong median carina, behind this, elevated and coarsely pitted, with the carina weak; elytra very broad in the center, roundingly angulate behind; the costal area attaining the center of the corium at the angle of the first sector.

Color: Grayish-brown; vertex and anterior third of pronotum brown, with the fine punctures black, median carina light, rest of pronotum light, with dark pitting; scutellum light-gray; elytra, ground color light, coarsely pitted with brown, becoming darker on the middle of the costa, either side of which there is a large subhyaline area, nervures mostly dark margined and distinct.

Genitalia: Female pygofers scarcely half longer than wide, moderately exceeded by the short ovipositor.

Described from a single female labeled "Cal.," received from Professor Bruner. Other examples have been examined, one of which bore Uhler's MSS. name as above. This species is similar in structure and color to *4-notata*, but readily separated by its shorter vertex, larger size and more uniform coloring.

APHROPHORA PARALLELA Say.

Cercopis parallela Say. Narr. Long's Expid. II, 304, 1824.
Ptyelus cribratus Walk. Homop. B. M. 712, 20 (fide Fitch).

Dusky reddish-brown, with two narrow, oblique, light bands on the elytra; body broad and deep, vertex long and the front much inflated; length 9–10mm., width 4–4.25mm.

Vertex, flat or slightly transversely depressed behind the tylus, fully one-half longer on middle than at eye, anterior margin thick, nearly straight to the tylus, tylus produced and rounded in front, its length equaling two-thirds of its width; front strongly inflated and produced, extending slightly beyond the vertex, its greatest inflation being nearly one-half greater than the long diameter of the eye: pronotum depressed on the anterior half, suddenly elevated and rounded on the posterior portion, the lateral margins long and sharply carinate, exceeding in length the distance between the ocelli; elytra broad and convex, narrowing behind: costal area very broad, but not reaching the center of the corium.

Color: Tawny, punctured with dark-brown; vertex, reddish-brown, finely punctured, the anterior margin shining black, interrupted on margin of tylus, median carina broadly white behind tylus; pronotum light-gray, heavily punctured with light tawny-brown; elytra grayish, heavily overcast with tawny, an interrupted light band running from the apex of scutellum to the center of costa and another starting in a spot on the inner margin at the apex of the clavus and running forward to meet the other on the costa; these bands are often reduced to white bars on the nervures, and are usually margined with darker.

Genitalia: Female pygofers, long and narrow, exceeded a full millimeter by the ovipositor; ultimate ventral segment of male short, its length about equaling its basal breadth, narrowing apically, the margins curving up and the lateral angles produced in the forms of style like appendages as long as the plates; plates nearly square, the posterior angles rounded.

Habitat: Specimens are at hand from Ontario, New York, Pennsylvania, Vermont, Massachusetts, Maryland, West Virginia, Michigan, and it has been reported from Nova Scotia, Ontario, Michigan, Illinois, Missouri, and Arkansas. The last two references probably refer to some other species, leaving it with a known distribution from Canada south to New Jersey, and west to Michigan and Illinois.

APHROPHORA IRRORATA n. sp.

Dark rusty-brown, flecked with lighter, very closely resembling *permutata*; longer and narrower than *parallela*, with a much shorter vertex and a less swollen front; length 11–12mm., width 3.5–4mm.

Vertex short, transversely depressed, only slightly longer on middle than at eye, anterior margin thin, tylus broad and short, nearly twice wider than long, median carina obscure, front moderately inflated, outline a regular curve from clypeus to vertex, angle with vertex acute, inflation of front less than the long diameter of the eye; pronotum transversely depressed before the middle, posterior disc elevated, carina weak except across the depressions, lateral margins short, their length less than the distance between the ocelli; elytra, long and narrow, much exceeding the abdomen, but little windened at center of costa: costal margins scarcely reflexed: costal area narrow, no more than one-half wider at the angle of the first sector than at the discoid cells.

Color: Vertex, dark rusty-brown, median carina and a spot either side the tylus, light; anterior half of the pronotum light, with few dark punctures except along the carina, posterior half densely punctured darker; elytra tawny, interrupted by numerous small circles of white, often inclosing a single dark puncture, these somewhat irregularly arranged, but usually showing three light areas, separated by two darker ones along the costa; an oblique light band from the center of scutellum to the center of the corium: a light spot before the apex of the clavus and another behind.

Genitalia: Female pygofers short and convex, exceeded by the short ovipositor by a distance of less than one-half their width: ultimate ventral segment of male abdomen longer than wide, narrowing behind, convex, shining; plates broad, parallel margined, inner posterior angles excavated, leaving a rounded notch nearly half their depth, outer posterior angles produced, acutely pointed.

Described from several examples received from Professor Bruner, taken in Sioux county, Nebraska (War-Bonnet Cañon), and others taken in Rist Cañon (Ft. Collins), Colo.

This species resembles *parallela* quite closely in color and marking, and was probably the one referred to by Say as occurring in Missouri and Arkansas. It is quite distinct structurally and may be readily separated by the short vertex, longer elytra and the striking differences in front and genitalia.

APHROPHORA PERMUTATA Uhl.

A. permutata Uhl. List Hemip. Colo. and N. Mex., p. 472, 1872 (Mss.).
A. permutata Uhl. List Hemip. West Miss. Riv., p 345, 1876 (Descrip.).
A. permutata Uhl. Stand. Nat. Hist., p. 243, 1884 (Distribution).

Varying from dark rusty-brown to brownish-yellow, with two oblique dark-margined, light bands on the elytra; resembling *irrorata*, but with a more inflated front, and longer, narrower male plates; length 9–12mm., width 3.5mm.

Vertex, sloping or transversely depressed, about one-fourth longer on middle than at eye, anterior margin moderately thick, nearly straight to the tylus; tylus moderately produced and rounded, fully twice wider than long; front moderately inflated, the inflation equaling the long diameter of the eye, produced anteriorly, forming a right angle with the vertex; pronotum somewhat depressed before the middle, disc elevated, the lateral margins about equaling in length the distance between the ocelli; elytra long and narrow, exceeding the abdomen: costal area less than one-half wider at the angle of sector than opposite the discoid cells.

Color: Vertex tawny, punctured with darker, carina light; pronotum grayish, coarsely punctate with tawny or rusty-brown; elytra tawny or grayish-brown, coarsely punctate with darker; an oblique, light band from the scutellum to the center of the corium, another from before the apex of clavus, running transversely on to the corium, then obliquely back to the costa, both bands broadly dark margined, the anterior one emphasized on the costa.

Genitalia: Female pygofers and ovipositor short and compact, thickly set with coarse hairs; ultimate ventral segment of male abdomen longer than its basal width, narrowing apically; plates in the form of long, tapering, finger-like processes, attingent until just before the black tip, where they narrow slightly and diverge.

Habitat: Specimens are at hand from Vancouver's island, Washington, Oregon, California, Idaho, Montana, and Colorado, and Uhler reports it from Utah.

APHROPHORA SARATOGENSIS Fitch.

Lepyronia saratogensis Fitch. Cat. Hom. N. Y., p. 53, 1851.
Ptyelus detritus Walk. List Hom. B. M., p. 713, 1851.
Ptyelus gelidus Walk. Hom. B. M., p. 714, 1851.

Fulvous or grayish-brown, a broad, median light stripe across head and pronotum, and oblique, light bands on the elytra; smaller than either *parallela* or *permutata*, and with a less inflated front; length 3.5–10mm., width 3–3.5mm.

Vertex, nearly flat, anterior margin thin, confluent with that of the tylus, which is also carinate anteriorly, making the entire anterior margin of the head thin and rounding, parallel with the posterior margin: front small, outline a regular curve, inflation less than the long diameter of the eye: pronotum only slightly convex, transverse depression before the middle very slight, carina weak, except across the depression; elytra moderately long and narrow, slightly exceeding the ovipositor in the female, costal margin scarcely reflexed.

Color: Vertex, fulvous with a broad, median light stripe; pronotum fulvous in front, grayish behind the middle, a broad, median light stripe, creamy yellow in front, broader, paler and including a few dark punctures behind the middle; elytra fulvous or grayish-brown, with the oblique, light bands broad and indistinct, rarely margined with darker.

Genitalia: Female pygofers half longer than their basal width, exceeded about one millimeter by the ovipositor, which is scarcely

exceeded by the elytra: ultimate ventral segment of the male abdomen very short, nearly four times wider than long, convex, the posterior angles produced, style like: plates subquadrate, rounded behind.

Habitat: Specimens are at hand from Ontario, New York, New Hampshire, District of Columbia, Maryland, and West Virginia, and it has been reported from Ontario, and Walker's species were from Nova Scotia and Florida.

Readily separated from *parallela* by its shorter vertex and smaller front, as well as its smaller size and lighter color; from *signoretii*, which it more closely resembles, by the light stripe and the male genitalia.

APHROPHORA ANNULATA n. sp.

Light ochraceous-brown, irregularly maculated with chestnut, lighter colored and more heavily marked than *saratogensis*, with a shorter female ovipositor and narrower, divergent male plates; length 10–11mm., width 3.5–4mm.

Vertex, flat, sloping, strongly angularly emarginate behind, roundingly angulate in front, scarcely longer in the middle than against eyes, anterior margin very thin either side tylus, tylus very broad and short; front moderately inflated, about equaling long diameter of eye, slightly anteriorly produced, forming very nearly a right angle with the vertex; pronotum strongly depressed on the anterior half, then suddenly elevated and rounded on the disc, the lateral margins short, sharp and oblique, scarcely as long as the distance between the ocelli, elytra moderately long, somewhat inflated, the costal margin reflexed anteriorly.

Color: Vertex, ochraceous, with a faint, median light line, bordered by two broad chestnut ones; pronotum pale, ochraceous, a chestnut stripe arising just before the middle on either side the carina and running backward, and then obliquely outward and broadening to the claval margin; disc of scutellum chestnut, the margins pale, elytra pale, ochraceous, an area at the base, an oblique band from the scutellum, broadening to just before the middle of the costa, another before the apex of the clavus and the nerve at the base of the apical cells, deep chestnut.

Genitalia: Female pygofers convex, scarcely longer than wide, ovipositor short and stout; ultimate ventral segment of the male abdomen nearly twice wider than long, subcylindrical; plates broad at the base, the outer margins flaring, inner margin cut off obliquely nearly to the base, slightly sinuate, leaving two widely divergent, black-tipped points.

Described from sixteen examples labeled "Wasatch, Utah, 6–27–91," received through the kindness of Mr. Otto Heidemann. Easily separated from *permutata*, which occurs in the same region, by the lighter color and heavier marking, as well as by the very distinct genitalia.

APHROPHORA SIGNORETII Fitch.

A. signoretii Fitch. Third Report Ins. N. Y., p. 70, 1856.

Tawny-brown, varying to pale ochraceous, line on vertex and pronotum and marking of elytra almost obsolete; slightly smaller than *saratogensis*, with a shorter, blunter vertex and stronger front; length 8.5–10mm., width 3.5mm.

Vertex, sloping or depressed, very obtusely angulate, anterior and posterior margins parallel, anterior margin sharp to the tylus, tylus distinct, slightly elevated; front moderately inflated, about equaling the long diameter of the eye, not produced anteriorly, forming an acute angle with the vertex; pronotum rather strongly depressed before the middle, but only slightly elevated behind, leaving it rather flat, side margins distinctly shorter than the distance between the ocelli; elytra moderately long, the costal margin reflexed anteriorly.

Color: Vertex, tawny, darkest on the tylus, carina obscurely marked; pronotum tawny-brown, scarcely a trace of gray on the elevated disc, anterior depressed portion lighter, scutellum lighter on the disc: elytra varying from tawny to ochraceous, light bands, not very prominent, the anterior one arising well back of the scutellum and not attaining the costa, the posterior one arising near the apex of clavus and running nearly transversely to the costa.

Genitalia: Female pygofers convex, moderately long, exceeded by the ovipositor, which does not reach the tips of the elytra; ultimate ventral segment of the male abdomen nearly twice longer than penultimate, one-half longer than its basal width, narrowing apically, disc convex; plates stout, forcep-like, black-tipped, their outer margins rounding, the inner ones obliquely divergent.

Habitat: Specimens are at hand from New York and Ontario, Canada.

This species has been confused with *saratogensis* to such an extent that it is impossible to separate the references; it may be readily distinguished, however, by the forcep-like male plates, while in *saratogensis* they are nearly quadrate discs.

GENUS LEPYRONIA A. & S.

Vertex, together with the eyes, as wide as the pronotum, angularly rounding anteriorly, the margin sharp, disc nearly flat, without carina, tylus large, parallel margined; ocelli about midway between tylus and pronotum, nearly as far from each other as from eyes; front broad, moderately inflated, coarsely ribbed, except along a median band; rostrum, two-jointed, reaching the middle coxæ; pronotum about three times as wide as its length on middle, anterior margin slightly rounding, lateral margins nearly parallel, sharply carinate, shorter than the long diameter of the eye, posterior margin deeply, roundingly emarginate, disc but slightly convex; elytra coriaceous, broad and rather short, outer margin broadly and regularly rounding to the acutely angulate apex; venation of the

normal pattern, often slightly irregular, obscured by the coriaceous structure and the dense pubescence; wings, with the third sector from the marginal one, forked, the intramarginal vein interrupted between the third and fourth sectors; legs short and stout, hind tibia armed with two stout spurs and a large crescent of spines: whole dorsal surface covered with a dense prostrate pubescence.

Our representatives of this genus are all grayish or brownish-cinereous, with traces of oblique fuscous-markings on the elytra; in size they range all the way from that of a *Clastoptera* up to the largest *Aphrophora*, but are always easily recognized by their globose forms and hairy covering.

SYNOPSIS OF THE SPECIES.

A. Margins of the vertex regularly rounding to the obtuse tip; elytra slightly angularly inflated, nearly twice longer than their combined width (folded), grayish, testaceous, with a distinct V on each elytron. *4-angularis* Say.

AA. Margins of vertex straight or concave, the tip slightly produced: elytra inflated, no more than one-half longer than their combined width (folded).

B. Small, testaceous, rather narrow; the vertex broad and short; shorter, or only equaling the pronotum in length; apex of elytra broadly subhyaline. *angulifera* Uhl.

BB. Large, nearly uniform grayish: general form globose; vertex longer than pronotum. *gibbosa* n. sp.

LEPYRONIA QUADRANGULARIS Say.

Cercopis quadrangularis Say. Jour. Acad. Nat. Sci. Phil., VI, p. 305, 1825.

Grayish or tawny-brown, with a fuscous spot at the base, another at the apex, and a V on the center of each elytron; margins of vertex convex; elytra only slightly inflated; length ♀ 7–8.5mm., ♂ 6.5–8mm., width 3mm.

Vertex, flat or depressed, length and width about equal, slightly longer than the pronotum, margins rounding to the blunt apex; tylus large, parallel margined, nearly one-half the length of the vertex; pronotum flat, twice wider than long, slightly rounding in front, with a transverse row of impressions behind the margin, lateral margins nearly parallel, longer than the short diameter of the eye; elytra about twice longer than wide, outer margin rounding, the apex angulate.

Color: Vertex and pronotum uniform testaceous, brown; elytra grayish or tawny-brown, a patch at the base, another at the apex, an oblique band from the tip of the scutellum to a point beyond the middle of the costa, another from the point of the clavus, meeting this on the costa and forming a V on each elytron, brownish fuscous.

Genitalia: Ultimate ventral segment in the female consisting of a narrow plate in each corner, pygofers and ovipositor short, elevated so that

the tip touches the elytra; male plates two and one-half times longer than wide, inner margins straight, outer narrowing slightly to just before the tip, where they are cut off obliquely, together forming a V-shaped trough, inclined slightly upwards.

Habitat: Specimens are at hand from Ontario, New Hampshire, New York, Pennsylvania, Connecticut, District of Columbia, Maryland, West Virginia, Georgia, Florida, Mississippi, Ohio, Iowa, South Dakota, Nebraska, Colorado and Texas.

LEPYRONIA ANGULIFERA Uhler.

Lepyronia angulifera Uhler. List Hemip. West Miss. Riv., p. 348, 1876.

Deep testaceous, with grayish-golden pubescence, the tips of the elytra broadly grayish, subhyaline; margin of vertex nearly straight, the tip produced; length ♀ 6mm., ♂ 5mm.; width 2.5mm.

Vertex sloping, disc convex, broader than long, about equaling the pronotum, margins slightly carinate, straight or sinuate, the apex produced; tylus narrow, parallel margined, one-half the length of the vertex; face moderately inflated, forming an acute angle with the vertex; pronotum more than twice wider than long, the anterior margin gently curving, back of which there is a series of depressions; lateral margins distinctly oblique; elytra coriaceous, distinctly angulate along the claval suture, the disc of the corium inflated, outer margin broadly rounding, apex roundingly angulate: width of apex of hind tibia one-third its length.

Color: Testaceous, elytra beyond clavus grayish sub-hyaline, the nervures darker, another light band across the middle, this latter often reduced to two spots on the centers of the costal margins; whole upper surface slightly grayish, irridescent from the pubescence.

Genitalia: In the female, similar to *4-angularis*, the ovipositor longer, exserted; male plates broad and convex at base, rapidly narrowing one-third their width, then nearly parallel margined to the rounding apex, about twice longer than their middle width, convex, inner margins attingent.

Habitat: Specimens are at hand from Jacksonville, Crescent City, Indian reservation, and Duval county, Florida, and Uhler reports it from Maryland and New Jersey.

The smaller size, narrower form and sloping, pointed vertex, as well as the subhyaline apex of the elytra, readily distinguish this species.

LEPYRONIA GIBBOSA n. sp.

Large; light-grayish brown, broader and more inflated than *4-angularis* or even the European *coleopterata*; vertex long, sloping, the margins concave; length ♀ 8–10mm., ♂ 6–7mm.; width ♀ 4–5mm., ♂ 3.5–4mm.

Vertex sloping, disc convex, longer than the pronotum, nearly as long as the width between the eyes, margins strongly concave in the male, slightly so in the female; tylus broad and distinct, the anterior margin elevated: front broadly inflated, the inflation being greater than the long diameter of the eye; pronotum only slightly rounded in front, behind which there is a transverse row of impressed spots, the lateral margins slightly oblique, as long as the eye, posterior margin short, deeply roundingly emarginate; elytra much broader than the pronotum, convex, sutural margin shorter than the greatest width, costal margin extending much below the level of the pronotum, broadly rounding, reflexed on the margin before the middle, behind which the disc is convex, apex bluntly roundingly angulate, whole upper surface covered with a dense, prostrate, golden pubescence.

Color: Grayish or fuscous-brown, with indistinct, darker markings on the elytra, as follows: A faint band from the point of the clavus, deepening into a spot behind the middle of the costa, sometimes traces of a band from here to the apex of the scutellum, forming an indistinct, fuscous V, a spot on the costa midway between the first and the apex.

Genitalia: Female pygofers and ovipositor as broad as long, inclined upwards, ultimate ventral segment only appearing as a long, triangular piece in each corner: male plates convex, nearly vertical, outer margins slightly narrowing, then rounding to the acute apex.

Described from two females and seven males, from the following localities: Little Rock, Iowa (O. & B.), Squaw Cañon, Sioux county; Sand Hills and Dismal River, Neb. (Bruner).

This species has several times been mistaken for *L. sordida* and is probably the one referred to as from Illinois under that species, in Goding's catalogue, as the true *sordida* has not yet been taken this side the Mexican boundary, or very close to it on the other side. The much larger size, lighter color and long, sloping vertex will at once distinguish it from *sordida* or the two preceding species.

GENUS PHILARONIA n. g.

Stout, heavy-set, somewhat globose forms of moderate size, having the form and dense hairy covering of a *Lapyronia* together with the sulcate vertex of a *Philænus* and a ramose venation, which is quite distinct from the type of either genus.

Vertex nearly rectangular in front, roundingly emarginate behind, distinctly longer on middle than against eye, nearly as long as the pronotum, anterior margin between eyes and tylus deeply sulcate, ocelli near the posterior margin, somewhat nearer each other than eyes, front strongly inflated and coarsely ribbed, except for a narrow median zone, rostrum short and stout, reaching only to the middle pair of coxæ, composed of two equal segments, head with the eyes scarcely as wide as the pronotum; pronotum rather small, scarcely elevated, the anterior margin

broadly rounded, side margins short, oblique, carinate, distinctly shorter than distance between ocelli, claval margin long, posterior margin deeply, narrowly emarginate; elytra coriaceous, slightly more than twice longer than wide, convex and inflated, widest across the discoid cells, costal margin sinuated and strongly reflexed just before the middle, venation irregular, ramose, the two veins on the corium forking to form discoid cells, which are broken up posteriorly to form an irregular network, which occupies the entire apical portion of the elytra, the entire venation obscured by a dense covering of fine hair.

This genus includes two rather anomalous species; from the ramose venation they might be placed next the *Cercopinæ*, while in other characters they fall between *Lepyronia* and *Philænus;* from *Philænus* and *Aphrophora* they may be readily separated by the dense prostrate pubescence and the venation, and from *Lepyronia* by the sulcate vertex. The genus is apparently confined to this continent and probably to the temperate zone, within which they are quite widely distributed.

The two species are still more remarkable in that they bear almost exactly the same relation to each other that the two species of *Philænus* do, *spumarius* and *abjectus* each possessing convex elytra and the forked wing vein, while *lineatus* and *bilineatus* are elongate and nearly parallel margined, with the third vein of wing entire; in color the resemblance is still greater, *bilineatus* being almost a duplicate, on a larger scale, of *lineatus*, even the variation in color following the same lines; while *abjectus*, in some of its lighter shades, exhibits traces of the maculation of a typical *spumarius*, and the darker ones differ by scarcely a shade from its darker varieties.

SYNOPSIS OF THE SPECIES.

A. Elytra convex, the costal margins strongly curved, much wider than across eyes, front not produced anteriorly, the outline a regular curve; third longitudinal vein of wing forked; color, reddish-brown. *abjectus* Uhl.

AA. Elytra with the costal margins nearly parallel, very little wider than across eyes; front, anteriorly produced, rapidly rounding to the vertex; color, pale straw-yellow, sometimes heavily marked with fuscous, costal margins lined with white. *bilineatus* Say.

PHILARONIA ABJECTA Uhl.

Philænus abjectus Uhl. List Hemip. West Miss. Riv., p. 346, 1876.
Lepyronia angulifera G. & B. Hemip. Colo., p. 71, 1895.

Form broad and convex, rapidly narrowing behind, *Lepyronia* like, head narrower than pronotum. Color reddish-brown; vertex and two spots on the costa lighter; length 5.5–6.5mm., width 2.5–3mm.

Vertex sloping, nearly rectangulate before, the sides rounded, sulcate, twice as long on middle as against the eye, length slightly more than half the width, posterior margin broadly rounding, the ocelli and suture between head and pronotum obscured by the heavy pubescence, ocelli equidistant from eyes and each other, nearer posterior margin than tylus; front moderately inflated, outline nearly straight, rostrum two-jointed scarcely equaling the front in length; pronotum with the anterior third depressed and on the same plane with the vertex, a row of pits along the posterior margin of the depressed area, side margins very short; elytra coriaceous, convex, the costal margin strongly curved, venation obscured, apically broken up and irregularly reticulate; legs very stout, spurs on hind tibia nearly twice as long as its width; whole dorsal surface densely pubescent.

Color: Reddish-brown: vertex and anterior part of pronotum often tawny, the pubescence golden, posterior part of pronotum and disc of the elytra dark reddish-brown, costal margin with a light spot on middle and a larger, obscure one towards the apex; front varying from creamy-yellow to tawny-brown.

Genitalia: Female pygofers very short and small, extending but little beyond the abdominal segments, strongly elevated, the ovipositer broad and short, nearly touching the suture; ultimate ventral segment of the male abdomen larger than penultimate, slightly convex, wedge-shaped; plates vertical, broad, wedge-shaped, the apex rounded, much larger and shorter than in *bilineatus*.

Habitat: Specimens are at hand from Colorado, Nebraska, South Dakota, and it is probable that Uhler's reference to *spumarius* from Utah, Dakota, Sitka, and Lake Winnipeg refer to this species.

PHILARONIA BILINEATA Say.

Aphrophora bilineata Say. Jour. Acad. Nat. Sci. Phil., VI, p. 804, 1831.
Philænus lineatus Uhl. List Hem. West Miss. R., p. 347, 1876 (in part).
Philænus lineatus G. & B. Hemip. Colo., p. 70, 1895.
Philænus americanus Bak. Can. Ent., XXIX, V, p. 112, 1897.

Form stout sub-cylindrical, the costal margins as seen from above, nearly parallel, head equaling the pronotum in width, vertex long, color pale-straw, costal margins broadly light, margined internally with darker; length 5.5–7mm., width 2mm.

Vertex long, rectangulate or slightly acute, the sides sulcate, length on middle nearly two-thirds the width, over twice the length against eye, tylus half the length of the vertex, distinctly carinate, ocelli nearer the posterior margin and very slightly nearer each other than the eyes; front strongly inflated, anteriorly produced, outline strongly curved, the inflation equaling the long diameter of the eye; pronotum almost flat, on same plane as the vertex, a median longitudinal depression the whole length, and two depressed spots on either side of the disc; elytra long, nearly parallel margined, broadly rounding behind, venation obscure on the disc, broken up and irregular ramose back of the middle; legs rather

long and slender, spurs on hind tibia small, scarcely longer than its width, the apical crown of spines very large; whole dorsal surface covered with a coarse golden pubescence.

Color: Straw-yellow clouded with fuscous, margins of sulcus both above and below, dark brown; vertex, pronotum and scutellum pale straw color, with two longitudinal brownish fuscous stripes enclosing a narrow median light one; elytra straw-yellow, the costal margin broadly white; inside this is a dark stripe arising against the eye and running back across the lateral margin of the pronotum and along the elytra inside the first sector to well beyond the middle; sometimes in the female, often in the male, it spreads out inwardly and darkens up the disc on the anterior two-thirds; front, yellowish, ribbed with darker; a light stripe arises under the eye and runs back to join the costal stripe; legs, straw-yellow.

Genitalia; female pygofers, short, stout, strongly elevated so that the tip of the exserted ovipositer touches the sutural margin of the elytra; ultimate ventral segment of the male abdomen very large, strongly convex, shining, plates vertical, wedge-shaped, over twice longer than their basal width, their tips nearly touching the elytra at the suture.

Habitat: Specimens are at hand from Idaho, Wyoming, Montana, Colorado, Nebraska, South Dakota, Iowa, New Hampshire, Ontario and Connecticut; Uhler reports it (as *lineatus*) from the Yukon, Mackenzie and Red River countries, and Baker (as *americanus*) from Massachusetts and Connecticut.

This is a very common species on the plains and prairies and extends eastward to the Atlantic coast. An examination of a type of *americanus* proved it to be identical with the forms that have been examined from other eastern localities and cannot be separated from the western ones. The only point of separation given in the description is "the flatter face of *lineatus*," and that character can be readily duplicated in western specimens.

GENUS PHILÆNUS Stal.

Vertex with the anterior margin obtuse or slightly acutely angulate, posterior margin rounding or very slightly angulate, longer on middle than against the eyes, over half the length of the pronotum, anterior margin between the eyes and tylus deeply sulcate, tylus distinct, anterior margin rounding, polished, ocelli near the posterior margin, nearly as far from each other as from eyes, front moderately inflated, coarsely ribbed either side the median line, disc flattened, clothed with coarse hairs, rostrum short and stout, composed of two equal segments, not extending beyond the second pair of coxæ; head together with the eyes about equaling in width the posterior part of the pronotum; pronotum weakly convex without a median carina, rounding angulate in front, deeply emarginate behind, the lateral margin much shorter than the distance between the ocelli, carinate, claval margins long and slightly emarginate; elytra over twice longer than wide, convex or paralled margined, without an appendix;

venation simple, both veins of the corium forking and forming two elongate discoid cells, apical cells somewhat irregular, usually about five; wings with the third vein from the marginal vein either forked (*spumarius*) or entire (*lineatus*); legs short and stout, spurs and spines strong; whole dorsal surface of insect thickly, finely punctured and clothed with a short prostrate pubescence.

The members of this genus are all rather small compact forms from 4.5 to 6mm. in length and about half that in width, they are apparently confined to the North Temperate zone; seven species have been recognized in Europe, two of which range clear across that continent and along the eastern section of this one, being the only representative of the genus in this country. They are quite different in form and appearance, and are readily separated by reference to a few structural characters, although the variation in color of one species is almost without limit and includes in its variations one that simulates the constant color markings of the other species.

SYNOPSIS OF THE SPECIES.

A. Vertex twice wider than long, tylus broad, occupying more than half the length of the vertex, elytra with the costal margin convex, much broader than across eyes; third vein of wing forked, forming a closed apical cell. *spumarius* Linn.

AA. Length of vertex equaling two thirds of its width, tylus narrow, occupying half the length of the vertex; elytra with the costal margin nearly parallel, scarcely wider than across eyes; third vein of wing not forked. *lineatus* Linn.

PHILÆNUS SPUMARIUS Linn.

Cicada spumaria Linn. Faun. Suec., 240, 881, 1761.
Ptyelus albiceps Prov. Nat. Can. IV, 351, Hemip. du Can., 258.
Philænus lineatus Prov. Hemip. du Can., 258.

Broad and short, the elytra strongly convex, flaring on the margin; head broad and short, sloping; color very variable; length 5.5–6.5mm., width 2–2.5mm.

Vertex short, sloping, twice wider than long, a little over one-half the length of the pronotum, anterior margin obtusely angulate, tylus broader than long, longer than the vertex behind it, ocelli placed close to the posterior margin, equidistant from each other and eyes: front broad, with seven or eight coarse ribs, outline only slightly curved, forming an acute angle with the vertex, the apex blunt: rostrum reaching on to the middle coxæ, as long as the front; pronotum roundingly angled in front, deeply pitted back of the margin; elytra broad, costal margin strongly convex, reflexed before the middle; venation simple, the outer vein forking just beyond the middle and forming an elongate discoid cell, fully five times as long as wide, angular at the fork; wings, with the third vein from the marginal one, forking before the apex.

Color: So variable that it can only be indicated under the varieties.

Genitalia: Female pygofers, broader than long, the ovipositor only slightly exserted; male plates broad at the base, gradually narrowing to the middle, beyond which they appear as tapering, finger-like processes.

Habitat: Europe, the New England states, Nova Scotia, and Ontario. Uhler records it from Utah, Dakota, Sitka, and Lake Winnipeg, but it seems probable that those references were to one or more of the other species, as it has not been found by anyone else in any of these localities, while both *bilineatus* and *abjectus* have.

In color this species is very variable; in Europe about fifteen varieties are recognized, ranging from pale, creamy-white, through variously spotted and lined forms, to a shining, jet black variety. These have not all been recognized in this country as yet, but as both the extreme, and several of the intermediate forms have, it has been thought best to give all the more strongly marked varieties indicating which ones are known to occur.

These varieties all intergrade and no hard and fast lines can be drawn in regard to them, but nearly all the examples will fall readily in to one or another of the following ones, the greater number probably belonging to the first.

Var. *ustulatus* Fall. Grayish-brown or tawny, the vertex and anterior half of the pronotum light, a large, light spot before the middle of the costal margin, and another, slightly smaller, behind.

Var. *fasciatus* Fabr. Vertex and anterior half of the pronotum golden-yellow, the rest of pronotum and elytra dark-brown or black, with an oblique band from scutellum, broadening to just before the middle of costa, and a spot behind the middle, sometimes extending to a spot at apex of clavus, white.

Var. *marginellus* Fab. Black; vertex and anterior half of the pronotum and a stripe on the costal margin of the elytra, yellowish-white.

Var. *leucocephalus* Linn. Dark-brown or black, vertex and anterior half of the pronotum yellow.

Var. *lateralis* Linn. Black; a broad, light stripe on costa.

Var. *leucophthalmus* Linn. Entirely dark-brown or black.

Var. *lineatus* Fab. Yellowish-white; a median black stripe arising, sometimes on the point of the vertex, sometimes on the pronotum, and extending to the apex of clavus, often enclosing a narrow, light line; a dark stripe on the corium, parallel with the first.

Var. *pallidus* Sch. Pale yellowish-white.

Whatever its color, it may be readily separated from *lineatus* by the broader, convex form, and the short, obtuse vertex.

PHILÆNUS LINEATUS Linn.

Cicada lineata Linn. Faun. Suec., 241, 888, 1761.
Ptyelus basivitta Walk. List Homop. B. M., 718, 1851.

Pale creamy-yellow with a light stripe along the costa inside of which may be a dark stripe. Smaller and narrower than *spumarius*, with the elytra nearly parallel margined, the head long and angular; length 4.5–6.5mm., width 1.5–2mm.

Vertex, flat, nearly right-angled before, the sides rounding, length equal to two-thirds of the width, almost as long as the pronotum, a faint median carina; tylus narrow, longer than width at base, about equal to the rest of the vertex; ocelli equidistant from tylus and pronotum and also from eyes and each other; front broad, strongly ribbed, making an acute angle with the vertex; rostrum short and stout scarcely reaching the middle coxæ, shorter than the front; pronotum small, flat, broadly rounded in front, usually three or four longitudinal depressions on the anterior portion of the disc; elytra nearly parallel margined, the costal margin curved inward on the middle, venation simple, normal, the outer sector of corium forking near the middle of the posterior half of the elytra, forming a broad discoid cell scarcely three times longer than wide, rounding at the fork; wings with the third vein from the costal vein entire.

Color: Above, pale creamy-yellow with a short prostrate, golden pubescence covering the entire surface, costal area of the elytra pale creamy-white becoming yellowish posteriorly, a dark stripe runs back from either eye crossing the pronotum below the carinate lateral margins, then on to the elytra where they follow the outer sector, fading out posteriorly, a dark spot on the suture just beyond the apex of clavus, sometimes continued as a dark margin around the apex of elytra. In some males the dark stripe spreads out inwardly and covers nearly the whole of the elytra inside the white margins. Front and below darker with a pale longitudinal stripe on either side just below the eyes.

Genitalia: Female pygofers no longer than their basal width, narrowing apically, exceeded by the long ovipositer, more than half their length; male plates broad at the base curving upward at nearly right angles to the abdomen, their inner margins straight, attingent, outer margins parallel or slightly narrowing to beyond the middle, then widening and forming an obtuse outward angle beyond which they are cut off obliquely, each plate three times longer than wide.

Habitat: (Europe). Specimens are at hand from St. Johns, N. B., New Hampshire, and New York, and it has been reported from Nova Scotia, Ontario and Maine. The reports from the middle and western states probably all refer to *bilineatus*, as that species is common in those sections, while *lineatus* has not been received from outside of the the eastern states The specimens from New Brunswick are smaller and inclined to be tawny and answer the description of Walker's species (*basivitta*) from Hudson's Bay so well that there seems to be no doubt but what

ongs here.

CUESTA TOPOGRAPHY OF THE CRIMEAN PENINSULA.

BY CHARLES R KEYES.

(Abstract.)

At the last meeting of the Academy I discussed briefly some aspects of the geographic development of the Crimea and the northern borders of the Black sea. Since that time certain of the photographs obtained by those who took part in the geological excursions following the International Congress of Geologists, have been received. It is to one of these especially that I now wish to direct your attention. It shows very clearly certain phases of the surface relief of which mention was made last year, and in a way that is rarely ever exhibited to such a great advantage or to such an extent. The photograph is one taken by Mr. R. T. Mallet of London, who was a member of the party. It is through his kindness I am now able to present it to you.

The photograph (plate vii) is, I think, the best one ever secured showing what modern geographers term Cuesta relief. The word cuesta is a recent American acquisition from the Spanish. It is a common word, used in southwestern United States and Mexico to express the same idea that we do by step-and-platform topography. The short, simple and expressive word has been seized with avidity and has been used widely in place of the longer phrase.

The development of the Cuesta type of surface relief is, briefly, this: A region of slightly tilled strata composed of alternating hard and soft beds is planed off or worn down to a peneplain, or a base-level plain. This grade-plain is one of faint relief, lying slightly above sea level. When such a region again suffers differential uplifting, the agencies of erosion actively begin to work anew Long lateral valleys are soon opened out in the soft strata along the strike of the rocks or at right angles to the direction of greatest dips. These

valleys are connected by narrow gorges. Abrupt escarpments form one side of the lateral valleys and long back-slopes the other. A series of gigantic steps are formed. The idea is best expressed by a cross-section (figure 4), which is a diagrammatic one, of the same region in which the photograph was taken.

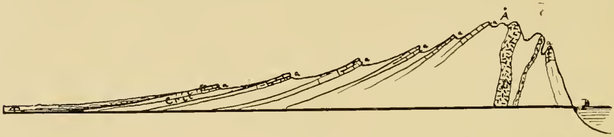

FIG. 4. Cross-section of the Crimea.

In this country we have some excellent examples of this type of topography. Besides the great areas in southwest United States, the Black Hills and Ozarks furnish excellent examples, but they are all on such a large scale that the camera cannot satisfactorily reproduce them. Nowhere in this country is it depicted so beautifully as in the region photographed. The photograph was taken from the crest of one of the lofty escarpments, just outside of the southern gates of the ancient city of Chufut Kaleh, formerly occupied by the Karaim Jews, but long since deserted and now in ruins. This point is about five miles from Bakhchisarai, 300 years ago the capital of the Tartar Khans, and about forty miles from Sevastopol. The resistant numbers of the couplets forming the escarpments are chalky limestones of Cretaceous age. To the north they are covered by Tertiary deposits.

In Iowa we have traces of an excellent illustration of Cuesta topography, in the area occupied by the upper coal measures of the southwestern part of the state. It is best shown, perhaps, in Madison county. Elsewhere it is greatly obscured by heavy drift deposits, which almost completely bury the highest escarpments. Only here and there do the latter peep out through the glacial *debris*. The broad, intervening valleys that once existed are filled by surface deposits to a depth often of 200 feet.

PERMIAN ROCKS OF EASTERN RUSSIA.

BY CHARLES R. KEYES.

(Abstract.)

In this country the Permian question has long troubled our geologists. For more than forty years it has been discussed, and up to the present time little advancement appears to have been made. Recently, interest has been awakened in the subject, and many workers have begun to attack the problems anew.

At first glance the title of this paper would seem to have little bearing upon our Iowa geology. Yet, it is directly to the Iowa part of the question that the present statements are intended to apply. The southwestern part of the state contains beds that have been placed in the Permian. In the consideration of the so-called Permian beds in America, few workers have been able to compare these formations directly with the original Permian. The information has been largely second hand, and the literature is to a great extent inaccessible on account of being in foreign languages and widely scattered.

During the geological excursions that preceded and followed the sessions of the International Congress of Geologists that were held in St. Petersburg a year ago, a number of American workers, interested in the Permian question, were able to examine pretty extensively the original beds constituting Murchison's system. The examinations were especially instructive, on account of the personal guidance of the Russian geologists, who had long worked in the region. Along the flanks of the Urals, and in the great valleys of the Kama and Volga rivers, the sections were particularly complete.

The most remarkable feature about the Russian Paleozoic strata above the Devonian is, that in nearly every respect, they are almost identical with the same parts of the general geological sections developed in the Mississippi valley, as found in Iowa, Missouri, and Kansas. And, strangely enough, the very

same questions that have so long perplexed investigators in this country, are momentous problems yet not fully solved in Russia. Yet, a comparison between the two widely separated provinces throws some light on our own perplexities.

The basins occupied by the upper Paleozoic in Russia, and the Mississippi valley, are very nearly of the same size. In the first mentioned area the Permian very greatly predominates as the surface rock; in the last named, the coal measures. The Carboniferous of Russia presents two very distinct aspects: a thalassic facies, occurring on the western flanks of the Urals, and made up of limestone chiefly; and a shallow water or littoral phase, that is coal-bearing, which is best developed in the southern and western parts of the great area, principally in the Donetz and Toula basins.

COMPARISON OF GENERAL SECTIONS.

RUSSIA.	CHARACTER OF TERRANES.	MISSISSIPPI VALLEY.
Tartaran, Permo-Trias: or Upper Permian, P_3.	Shales and marls, red and variegated, sandstones. shaly, fossils rare, "red beds."	Cimarron series.
Middle Permian, P_2.	Limestones, some dolomitic, and calcareous marl.	Marion li. } Series.
Lower Permian, P_1b.	Shale, only 200 feet thick in Kama valley.	
Upper Permo-Carboniferous (base of equal P), CP_c.	Limestone, heavy, dolomitic.	Chase li. } Series.
Artinsk, CP.	Shales, sandstones, some thin limestones.	Neosho. Cottonwood. Wabaunsee.
Upper Carboniferous, C_3.	Limestones and shales, highly fossiliferous.	Missourian series.
Moscouan, Middle Carboniferous, C_2.	Shales, sandstones, thin limestones, coal-bearing.	Des Moines series.
Lower Carboniferous, C_1.	Limestones chiefly, some shale and sandstone.	Mississippian.

In the consideration of a theme like the present one it is recognized at the outset that comparisons of terranes of different geological provinces involve no necessary exact synchrony, except through absolute physical means of correlation. Such a standard, independent of intrinsic features of the terranes is not yet formulated for widely separated districts. The shortcomings of the common fossil criteria, in any other than the most general way and in the absence of something better, are well known. Any agreement of biotic features in stratigraphic successions distantly removed from one another are

looked upon, so far as indicating their simultaneous origin, only as happy accidents. Instead of furnishing proofs of time equivalency it suggests for similar faunas merely likeness of conditions, irrespective of time. Such faunal facies are only biologically representative. They are merely homotaxial.

In lithological and faunal characters the rocks are so nearly alike that it is difficult to fancy that in the Urals one is on the opposite side of the earth from our Iowa and Kansas beds.

Among the pertinent questions regarding the so-called Permian in this country three are of special prominence. They are: (1) Should the Permian be recognized in America? (2) If so, what is the taxonomic rank? and (3) what are the upper and lower limits of the terrane, so-called? Without going into details of these questions it may be suggested:

First.—That while we have in America a great succession of deposits identical in all essential respects to the original Permian of Russia, the two great basins merely had similar histories that are not necessarily connected, and probably were wholly independent of each other and unrelated; that the Russian Permian constitutes a geological province by itself; and that therefore the term Permian should not be used as a technically exact term in connection with the Mississippi valley deposits.

Second.—That Permian as originally proposed applies to a provincial series, and according to our usual standard, has at best a taxonomic rank below that of system. Also, in view of the possible elevation of its subdivisions to the rank of series the term will have no position in the scheme of classification. It will be, no doubt, eventually dropped altogether, the various series belonging to the succession being made a part of the Carboniferous system. In this country the same plan has already been proposed.

Third.—That, with the solution given to the second question, it is unnecessary to attempt to locate the limits of the so-called Permian in this country. The divisional lines of the series comprising the beds of the typical American section in Kansas are already well defined, with the possible exception of the upper member.

The data upon which these conclusions are based are given at length in another place.

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